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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 87.
L. O. HOWARD, Entomologist and Chief of Bureau.

REPORT ON THE FIELD WORK AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

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BY

D. M. ROGERS,
Special Field Agent,

AND

A. F. BURGESS,
Expert in Charge of Breeding Experiments.

ISSUED AUGUST 13, 1910.

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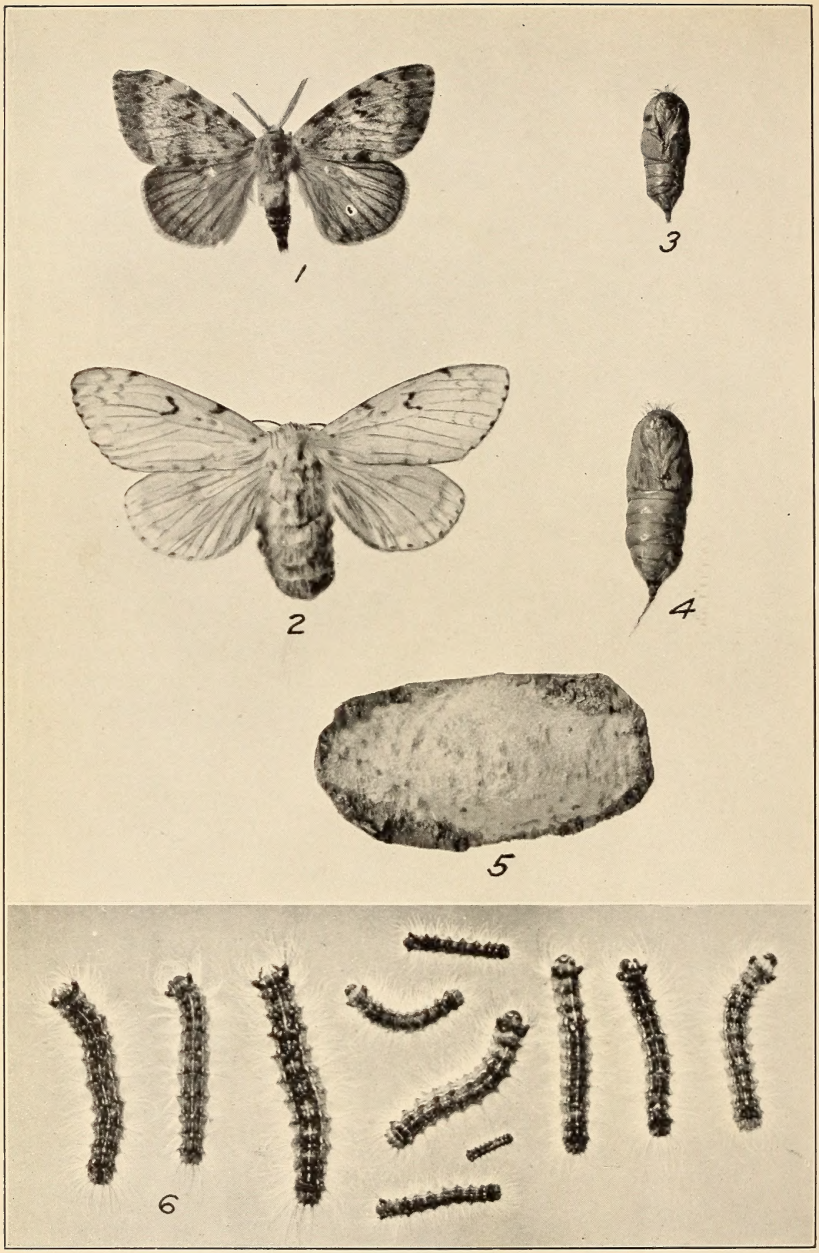

THE GIPSY MOTH (PORTHETRIA DISPAR).

Fig. 1.—Male moth. Fig. 2.—Female moth. Fig. 3.—Male pupa. Fig. 4.—Female pupa. Fig. 5.—Egg cluster. Fig. 6.—Caterpillars; the largest are less than half grown. (Original.)

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 5, 1910.

Sir: The only accounts so far published by the Department of the large-scale work which is being carried on under congressional appropriations in the effort to limit the farther spread of the gipsy moth and the brown-tail moth in New England have been brief statements in the annual reports of the Chief of the Bureau of Entomology. The work has now reached such a stage that a comprehensive account of the work accomplished, the methods of work, and present conditions, is demanded. I therefore have the honor to submit for publication the accompanying manuscript, which includes a report on the field work for preventing the spread of the gipsy moth and the brown-tail moth, and which has been prepared by Messrs. D. M. Rogers and A. F. Burgess, of this Bureau. This report does not include a consideration of the efforts made to import and acclimatize the European and Japanese parasites of the gipsy moth and the brown-tail moth. That matter will be described in another bulletin. I recommend that the accompanying manuscript be published as Bulletin No. 87 of this Bureau.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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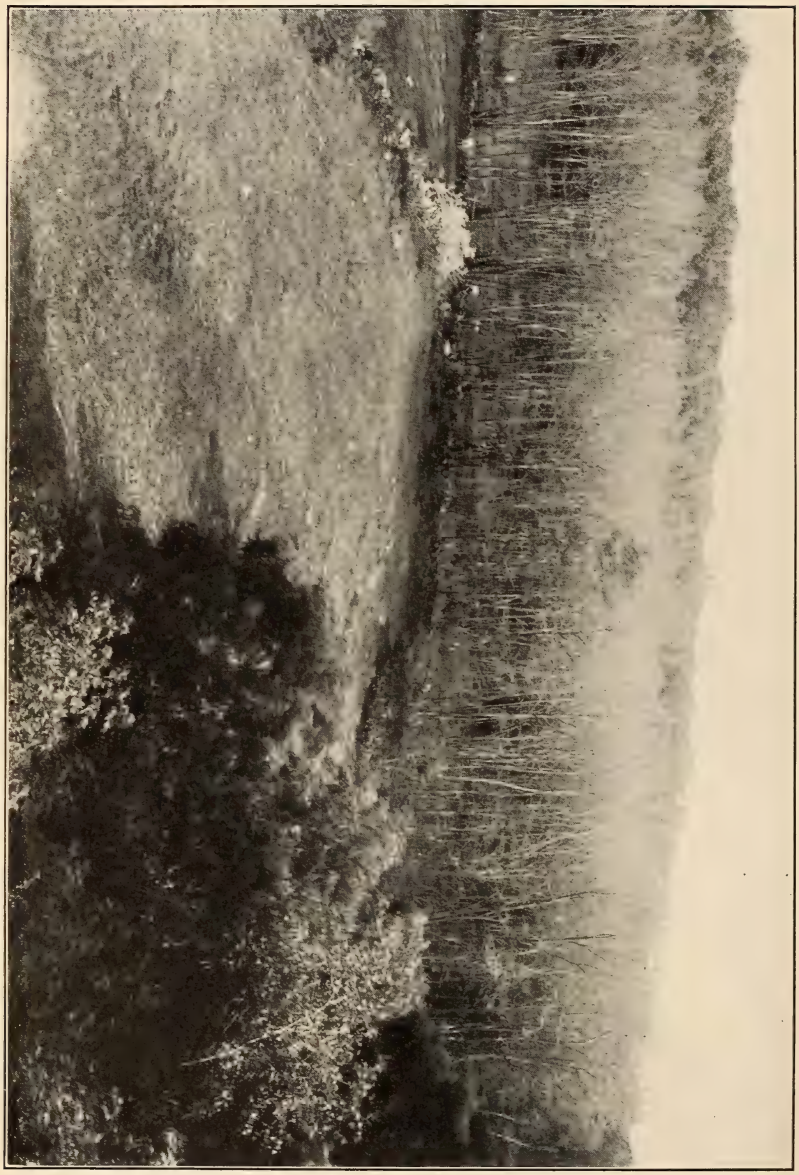


WOODLAND AREA IN MASSACHUSETTS DEFOLIATED BY THE GIPSY MOTH. (ORIGINAL.)

REPORT ON THE FIELD WORK AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

INTRODUCTION.

For nearly two decades eastern Massachusetts has suffered enormous loss to its forest, orchard, and shade trees, as well as to ornamental plantings which beautify many of the large country estates, by reason of the depredations of the gipsy moth (*Porthetria dispar* L.) (see Pl. II), and for the latter half of this period by the combined injury caused by this insect and the brown-tail moth (*Euproctis chrysorrhœa* L.). Both of these insects were introduced from Europe. During the past few years the situation became so serious, owing to the spread of these insects into Maine, New Hampshire, Rhode Island, and Connecticut, that appropriations from the National Government were urged by the States affected, and, owing to the great danger that these pests would become disseminated over the entire country, funds have been appropriated by Congress to assist in securing their control and of preventing further spread. The purpose of this report is to sketch briefly the life histories of the insects concerned, their habits since their introduction into this country, a statement of the injury caused by them here and in their native homes, and to discuss the methods used for their control, in order that this work may become better understood and the danger of the presence of the pests more thoroughly appreciated in sections which are not now infested. Free use has been made of the reports already published by the State of Massachusetts and other New England States, where warfare against these insects has been carried on in the past.

Acknowledgment and thanks are due to Dr. W. E. Britton, state entomologist of Connecticut, for the use of Plate III, figure 1, and to Prof. E. F. Hitchings, state entomologist of Maine, for the use of Plate VIII and text figure 16.

IMPORTANCE OF THE GIPSY MOTH AS AN INSECT PEST IN THIS COUNTRY.

During the summer of 1889 great injury was caused to the foliage of the street trees and of those on private estates in Medford, Mass.,

a city about 5 miles north of Boston, by caterpillars which appeared in enormous swarms. In many cases the trees were completely defoliated, and the insects crawled into the houses and upon the fences and walks, so as to become a public nuisance in the neighborhood. Specimens were sent to the office of the Massachusetts state board of agriculture at Boston, and were transmitted to Prof. C. H. Fernald, at Amherst, and, in his absence, were determined by Mrs. Fernald as the gipsy moth of Europe. An investigation in the neighborhood showed that this insect had been quite abundant and had caused considerable damage for a number of years, but, owing to the belief of most of the residents that it was one of the common native caterpillars, no action had been taken in the matter. As a result of persistent inquiry among the inhabitants of the infested section it was determined that some of these insects were introduced from Europe, probably in the egg stage, by Prof. Leopold Trouvelot, a French naturalist, about the year 1869. At that time this gentleman was conducting experiments with silkworms, and also with some of the American species of silk-spinning caterpillars. The evidence seems to show that some of the egg clusters, or young caterpillars, which he secured from Europe, escaped from his house where the experiments were being conducted, and, as he was aware of the dangerous nature of the insect in its native home, he destroyed all the caterpillars that could be found in the neighborhood and made public the fact that it had escaped. At that time the section in which he resided adjoined a large area of waste land, which was overgrown with sprouts and brush, and here the species became established. Its slow development as a serious pest was undoubtedly due to the fact that this area was burned over periodically by brush fires which destroyed large numbers of the insects, and also to the prevalence at that time of many insectivorous birds, which doubtless accomplished much in preventing the rapid increase of the species.

So thoroughly were the trees defoliated by the caterpillars that in many cases during the summer of 1889 and 1890 swarms of them practically covered the sides of many houses. Real estate in the neighborhood rapidly depreciated in value and many tenants moved to more congenial quarters of the city. The recorded statements of eye-witnesses of the conditions that prevailed seem almost incredible to one who has had no opportunity to observe the serious damage which this insect causes. Many trees and orchards died as the result of repeated defoliation, and during the winter of 1890, on petition of the city of Medford and the surrounding cities and towns, the matter was brought to the attention of the legislature, and the sum of $25,000 appropriated for abating the nuisance.

STATE WORK AGAINST THE GIPSY MOTH IN MASSACHUSETTS, 1890–1900.

The work against the gipsy moth was placed in charge of a paid commission of three men, appointed by the governor. At the time the work was begun it was thought that only a small area was infested, but on May 9, 1890, the commission reported to the governor that the infested area was "some sixteen times as large as at first represented," and requested an additional appropriation of $25,000, which was granted.

Early in 1891 the commission was abolished by the governor and an unsalaried one appointed which carried on the work for a few months, until a law was enacted by the legislature giving the state board of agriculture authority to use "all reasonable measures to prevent the spreading and to secure the extermination of the *Oeneria dispar* or gypsy moth in this Commonwealth."

The board placed the work under the immediate direction of a committee, later known as the "Committee on gypsy moth, insects, and birds," which was made up of five of its members, who served without pay. Mr. E. H. Forbush, of Worcester, Mass., was appointed director of the field work, and Prof. C. H. Fernald, entomologist to the Massachusetts agricultural experiment station at Amherst, was given supervision of the experimental and scientific work, and energetic measures were at once begun to exterminate the pest, and were continued until February 1, 1900.

RECORD OF THE GIPSY MOTH IN ITS NATIVE HOME.

A perusal of the European literature concerning this insect, which was thoroughly examined and the results presented in the report on the gipsy moth by Forbush and Fernald, published by the Massachusetts board of agriculture in 1896, indicates that it was a pest in nearly all European countries at the time the first entomological writings were published, and there is good reason to suppose that even before that time much serious devastation to trees and forests resulted from it, although it was probably referred to as "the plague," and was believed by the inhabitants to be a scourge sent by the Almighty as a penalty for their wrongdoings. Many cases are on record where this insect became abundant and defoliated thousands of acres of forests, as well as the fruit and shade trees and shrubs in the populated regions. The literature indicates that this moth is abundant periodically and causes enormous loss throughout continental Europe, western Asia, and Northern Africa. It has been found as far north as Stockholm and is known to occur in Algeria. Slight, though not serious, infestations have been reported in England, and this or a closely allied species occurs in Japan, and is said to be present in sections of China. During the year 1909, Prof.

Trevor Kincaid, who was engaged by the Bureau of Entomology, in cooperation with the State of Massachusetts, for the purpose of collecting parasites of this insect in Russia, found during his explorations that thousands of acres of forests were completely denuded, and in other localities trees were dying over large areas as a result of previous defoliations. Dr. L. O. Howard, Chief of the Bureau of Entomology, while visiting, in 1909, the corps of European agents engaged in collecting parasites of the gipsy moth in Europe, found a large forest area near Nantes, France, which was completely stripped by this pest. In fact, the whole European history of this moth is a continuous record of periodical outbreaks of greater or less severity, which have caused enormous damage to trees from the time of the earliest writings on entomology down to the present time. The situation in Japan is not as serious as in Europe, owing to the efficient work of certain parasites which tend to keep the insect under control.

LIFE HISTORY OF THE GIPSY MOTH.

THE EGGS.

(Pl. I, fig. 5.)

The female gipsy moth deposits her eggs in clusters containing normally from 400 to 500 eggs, which are covered with hair from her body; this protects them from the action of the elements and renders their destruction, even by fire, quite difficult. The clusters are fully 1 inch in length and about half as wide, and have the general appearance and color of a small piece of sponge. The number of eggs varies considerably and depends largely on the food supply and the vigor of the caterpillar from which the female develops. In colonies where the food supply has been practically exhausted by the larvæ, egg clusters are often found containing not more than 50 or 75 eggs, while, on the other hand, a number of cases are on record where single clusters contained over 1,000 eggs. The majority of the eggs are deposited about the middle of July, although there is considerable seasonal and individual variation. Females have been found depositing egg clusters as early as June 25 and as late as October 7. Crevices in the bark, holes in trees, stone walls (Pl. III, fig. 2), or rubbish piles are favorite places for the deposition of eggs, as they afford shelter for the full-grown caterpillar about to pupate and protect the pupa and the newly emerged moth. Many clusters are deposited under steps or porches of houses, in outbuildings near infested trees, as well as on the trunks (Pl. III, fig. 1) and on the under side of the branches of the trees themselves. Hatching takes place early in the spring, about the time the trees are coming into leaf. A few cases are on record where the caterpillars hatched in the fall, but this is unusual.

FIG. 1.—EGG CLUSTERS OF THE GIPSY MOTH ON TRUNK OF APPLE TREE, WALLINGFORD, CONN., DECEMBER, 1909. (FROM BRITTON.)

FIG. 2.—EGG CLUSTERS OF THE GIPSY MOTH ON STONE WALL. (ORIGINAL.

[This wall has been overturned to expose the egg clusters.]

THE LARVÆ.

(Pl. I, fig. 6.)

The newly hatched caterpillars feed upon the small leaves, making "pin holes" in them. As a rule the caterpillars molt five times, but quite a number of cases are on record where an additional molt took place before they entered the pupal stage. The newly hatched caterpillars are about one-eighth of an inch in length and covered with long, slender hairs. During warm weather they feed upon the leaves, but when the temperature is low, or during rainy or unsettled weather, such as is common in early spring, they congregate in masses in the crevices of the bark or on the egg clusters from which they hatched. As the weather becomes warmer in the early summer, they grow rapidly and devour the entire leaves except the woody veins. Until they are about half grown, the caterpillars are able to suspend themselves from the twigs or branches of the trees by means of silken threads spun from their bodies, and in this way they often drop upon animals, carriages, or other moving objects, and may be conveyed to localities where none of the species exists. After the caterpillars have molted the fourth time, which usually occurs about the middle of June, a considerable change in coloration appears. On the dorsum of each of the first five segments behind the head is a pair of prominent blue tubercles, while on the following six segments the tubercles are of a dark-red color. The arrangement and coloration of these tubercles is characteristic of the species. The feeding habits change somewhat with the progress in growth of the caterpillars, for after becoming half grown the caterpillars seem to prefer shelter from the sun and feed for the most part at night or during cloudy weather. During the warm part of the day they remain concealed in crevices in the bark, crawl to the ground, or seek any convenient shelter from the sun. This habit serves as a protection against their natural enemies, and although in moderately infested sections it is usually possible to find caterpillars feeding at midday during sunny weather, still the majority are either in hiding or are feeding in such situations as to be largely protected from direct sunlight. The period spent in the caterpillar stage extends, on the average, from early in May to July 5, or is approximately seven weeks. Egg clusters deposited in cool situations do not hatch as readily as those more favorably located; hence the entire length of the feeding period varies considerably. Larvæ have been found as early as the 1st of April and as late as September 6. In certain areas along the seacoast and on islands which are surrounded by tidewater, the hatching of the eggs is retarded, and pupation takes place much later than where conditions are normal. The full-grown caterpillars measure about 2 inches in length, although there is considerable variation in this respect, due largely to the

amount of food available. It is a noticeable fact that in bad colonies, where most of the foliage has been eaten, the caterpillars pupate early in the season before attaining normal size.

This insect has a varied list of food plants; in fact, it will eat almost any kind of vegetation, although it seems to prefer the foliage of oaks (fig. 1), willows, and apple trees. Repeated observations have shown that the ash (fig. 1), juniper, and red cedar are practically immune from attack, while the maple is not injured to any great extent if more desirable food is within easy reach. Grass and garden crops are sometimes seriously injured when the supply of other food has been exhausted.

A few years ago a farmer in Lynn, Mass., stated that with the assistance of his men he collected several bushels of the caterpillars that were

FIG. 1.—Roadside view in Massachusetts, showing oak and ash trees, the former killed by the gipsy moth (*Porthetria dispar*) and the latter practically uninjured. (Original.)

feeding in his field of sweet corn. The caterpillars had stripped the trees in a piece of woodland near by, and, after eating all the foliage from the bushes and low growth, had migrated in countless numbers across the road and attacked the growing corn.

Most of our native leaf-eating insects confine their diet to a small number of food plants, and it is unusual for a species to feed on both deciduous and coniferous trees. The gipsy-moth larvæ, after becoming half grown, feed with avidity on conifers, especially the white pine, and many acres of this, as well as other coniferous trees, have been defoliated and killed in the infested region of New England (fig. 2).

The white pine, as well as the spruce and the hemlock, is unable to survive after one complete defoliation, and when only partially denuded the trees are usually attacked by bark borers and other insects so that death soon follows. The proper treatment of conifers to prevent injury by the gipsy moth will be described farther on in this report.

THE PUPÆ.

(Pl. I, figs. 3, 4.)

After the caterpillars have finished feeding they usually select more or less protected places in which to pupate. Stone walls, rubbish piles, and open spaces beneath porches or outbuildings furnish excellent places for caterpillars to enter the pupal stage. Of course, a large number remain on the trees, where they usually pupate on the under side of the branches, beneath loose bark, or in holes and cavities, or

FIG. 2.—Pine trees killed by the gipsy moth. (Original).

descend to the base of the trees before transforming. Previous to pupation the caterpillar spins a few threads of silk in order to attach itself firmly. The body then shortens considerably and pupation is accomplished by the integument of the segments behind the head splitting dorsally and the whole larval skin is forced back to the end of the body, the pupa remaining beneath the network of silk which held the caterpillar in place. The pupa is dark reddish-brown, and the body segments bear yellow hairs, which are arranged in groups. From 7 to 17 days are spent in this stage before the moth emerges. As a rule female pupæ are much larger than those of males, but the sex can always be determined by the structure of the last segment of the abdomen.

THE ADULTS.

(Pl. I, figs. 1, 2.)

The male moths ordinarily emerge from the pupæ earlier than do the females. The body of the male is light brown and the wings are considerably darker and have prominent black markings. Male moths are able to fly considerable distances and are especially active during warm sunny weather. The zigzag motion of the flight of these moths is characteristic of the species. The body of the female is light buff. The abdomen, which is very large and almost completely filled with eggs, is densely covered with short yellow hairs which are used by the moth to protect the eggs as they are deposited in the cluster. The wings are white, with prominent black markings, and, although they are apparently of ample size, the female moth is not able to fly on account of the weight of the body. The adult insects take no food, and after mating, which takes place soon after emergence from the pupa, the female begins depositing eggs. As a rule the egg cluster will be found near the pupal case from which the female emerged, but occasionally the moth will crawl a considerable distance, especially if disturbed. When a search for egg clusters is being made the discovery of a female pupal case is indication that an egg cluster is present near by. Sometimes moths which emerge from pupæ that are attached to the branches of trees fall to the ground and deposit their eggs on the trunks of surrounding trees or on leaves or rubbish. By the time the egg cluster is completed, the abdomen has shrunken greatly and in a few hours the moth dies.

METHODS EMPLOYED IN WORK AGAINST THE GIPSY MOTH.

SCOUTING.

As the law enacted by the Massachusetts legislature in 1891 required the state board of agriculture "to prevent the spread and secure the extermination" of this insect, a determined effort was made to ascertain the extent of the area infested. Men were trained so that they were able to recognize the moth in all its stages, and as soon as they had secured sufficient experience the most expert ones were sent into the territory not known to be infested to make a thorough inspection. As a result of this work, it was found that, while the area supposed to be infested in 1890 covered 9 cities and towns in whole or in part and embraced about 50 square miles, the pest had become established in more or less numbers in 30 cities and towns, covering an area of 200 square miles. This spread had undoubtedly been going on for a number of years, and as the thickly settled sections became badly infested the small caterpillars were easily conveyed long distances owing to their habit of spinning down from trees onto vehicles or other moving

bodies. Many colonies were discovered on the premises of milkmen and market gardeners who made regular trips to the infested section to distribute their products.

SPRAYING.

It was at first believed that this insect could be successfully controlled, like most other leaf-eating species, by spraying the trees with Paris green, a remedy which was then in common use. Experiments, however, showed that it was impossible to kill the caterpillars with this spray after they became half grown, unless it was used so strong that it resulted in severe injury to the foliage of the trees. Mr. F. C. Moulton, who conducted an extensive investigation with insecticides in the years 1891 and 1892, was able to prepare a new insecticide, arsenate of lead, which could be used in sufficient strength to kill the caterpillars without injuring the foliage. This work was later taken up by Messrs. A. H. Kirkland, F. J. Smith, and A. F. Burgess, under the direction of Prof. C. H. Fernald. A large number of experiments were made, using different formulas, which demonstrated the practical effectiveness of this poison and the proper method of its preparation. The poison as used at that time was made by dissolving the proper amounts of arsenate of soda and acetate of lead salts in separate vessels containing water. These solutions were then brought together and a precipitate, consisting of arsenate of lead, was formed. Usually the fresh precipitate was prepared in the field. In recent years, since this poison has come into general use throughout the country for treating trees infested with leaf-eating insects, it is made by manufacturers in a similar way, and is put on the market in the form of a paste which mixes readily with water, thus preventing the delay occasioned by mixing the raw chemicals and obviating the danger of securing impure materials, which might cause injury to the foliage or crop treated.

Some improvements were made in spraying machinery, which was very crude when we consider the equipment used at the present time. Spraying with the facilities then at hand was a very expensive operation, and in many cases gave unsatisfactory results, especially when large trees were treated. Owing to these facts, and because every effort was being made to secure the extermination of the insect, spraying was undertaken only in a limited way.

BURLAPPING.

The secretive habits of the caterpillars suggested the provision of artificial hiding places, and for this purpose burlap bands were placed about the trunks of the trees. Bolts of burlap were cut into strips about 8 inches wide, which were rolled for the convenience of the workmen. A band was placed around each tree about as high as a

man's shoulder and fastened in the center with twine, the upper part being folded down, forming an excellent shelter for the caterpillars. By examining the burlaps frequently and crushing the larvæ underneath great progress was made in destroying the pest. The free edges of the burlap should be kept loose from the trees so that the larvæ can easily crawl under the folds. This method can not be used advantageously until the caterpillars are about half grown, as they do not often seek shelter until that time. The expense entailed is considerable, but it is one of the most effective measures where extermination of the insect is desired.

STICKY BANDS.

Numerous attempts were made to use a sticky material, such as printer's ink, tar, or other substances, applying them to bands of tarred paper on the trunks of trees to prevent the caterpillars from ascending. Several tons of a German product, known as "raupenleim," were tried but none of these preparations proved satisfactory for wholesale use. Success in using such bands was not attained until the material known as tanglefoot came into use, about five years ago.

CUTTING AND BURNING.

In order to prepare infested territory so that it could be treated effectively and economically, it was necessary to cut out and burn the brush and sprout growth, as well as trees that were hollow and partially decayed. This method reduced to a minimum the number of trees to be burlapped or otherwise treated, and by removing the low growth the larvæ were forced to feed on the trees where they could be more easily destroyed.

A method employed against the young caterpillars hatched from egg clusters located in stone walls or rocky areas was to clean out all brush and undergrowth during the winter. As soon as the larvæ appeared in the spring the ground and walls were burned over by using a device known as a cyclone burner. This consisted of a 15-gallon oil tank, on which was mounted a small force pump. The oil was conducted through a hose to an iron extension rod, at the end of which a nozzle of the Vermorel type was fitted. The fine mist of oil forced from the nozzle was ignited and the ground and walls burned over. To secure best results a large ball of flame should be maintained which can be forced into the cracks or cavities in walls or ledges in order to destroy the larvæ. Paraffin gas oil or a light grade of crude petroleum can be used. Two men are required to operate this outfit satisfactorily. The action of the oil soon destroys the hose, so that it seldom lasts more than one season.

PRUNING.

As the female moths deposit their egg clusters under loose bark and in holes and cavities in the trees, and also because the larvæ seek such hiding places, it became necessary to rid the trees of these natural shelters. To accomplish this purpose a considerable amount of pruning and filling of cavities was required. This work had to be skillfully done, especially when fruit or shade trees in cities or towns were treated. Many ingenious methods were devised for carrying on these operations, some of which have been adopted by professional foresters and others who have taken up the business of caring for trees.

TREATING EGG CLUSTERS.

The insect exists in the egg stage nearly nine months in the year and many experiments were tried to determine the most effective method of treating egg clusters. The first method used was that followed in Europe and consisted simply in scraping off the egg masses and burning them. In removing the eggs many were scattered, even if the work was carefully done, and as such eggs hatched in due time it became necessary to secure a better method of treatment. It was found that they could be killed by saturating the clusters with crude coal-tar creosote to which was added a small amount of either coal tar or lampblack to discolor them and enable the workmen to tell instantly the ones that had been treated. (See fig. 3.)

FIG. 3.—Trunk of pine tree, showing tanglefoot band and egg clusters that have been treated with creosote. (Original.)

It was necessary to make a very thorough search of all objects likely to harbor egg clusters if satisfactory results were expected, and this required much climbing of high trees as well as careful ground work. The pupæ and moths were crushed or treated with creosote when found by the workmen.

It was necessary to apply a combination of methods to secure satisfactory results and many localities had to receive special treat-

ment on account of their location and condition of infestation. Methods which could be readily applied in wooded areas were entirely unsuited for use in residential sections.

DISCOVERY OF THE BROWN-TAIL MOTH IN AMERICA.

The work on the gipsy moth resulted in a great reduction of the numbers of the insect and a steady improvement in the condition of the infested territory, in spite of the fact that the legislature seldom granted the appropriations which were deemed absolutely necessary by the board of agriculture, and the availability of the funds was often delayed so that many of the trained men were thrown out of employment for a part of the year, which of course greatly affected the efficiency of the force. To add to the difficulties of the situation complaints were received during the summer of 1897 that trees and shrubs in Somerville, Mass., were being severely injured by an insect which appeared to be new to the region.

An investigation showed that the trouble was caused by the brown-tail moth (*Euproctis chrysorrhœa* L.), an insect well known and at times as noxious in Europe as the gipsy moth.

Careful inquiry indicated that this species was probably imported from Europe a few years before on rose or nursery stock by a local florist. The attention of the governor was called to the matter by the state board of agriculture, and, realizing the seriousness of the pest and the desirability of stamping it out at once, he sent a special message to the legislature, which was then in session, suggesting that action be taken without delay.

A law was passed requiring property owners to destroy the insects on their premises, and the opportunity for stamping out the pest before it could become generally disseminated was lost. As is always the case, some of the citizens and municipalities made every effort to destroy the pest, but through the neglect and indifference of others little permanent good was accomplished.

The following year $10,000 was diverted from the gipsy moth appropriation to "prevent the spread of the brown-tail moth," but the money did not become available for use until after the caterpillars had left their winter webs and begun feeding. Thus the insect was allowed to spread for two seasons after it was discovered, because the work was not taken up promptly under proper supervision. When work was begun it was found that the insect had spread over a large territory and it seemed almost impossible to stamp it out. A detailed account of this insect was prepared by Fernald and Kirkland in 1903 and published by the Massachusetts board of agriculture.

EUROPEAN HISTORY OF THE BROWN-TAIL MOTH.

The brown-tail moth is one of the oldest known pests in Europe and is called in many of the earlier writings "la commune," or the communistic one. It is said to be distributed over central and southern Europe and to extend to Algiers on the south and the Himalayas on the east. It has been found in limited numbers in England and may be present in Japan, although the record from the latter country is somewhat doubtful. Few, if any, species have caused more havoc to foliage than has this one, and many accounts of its destructive work have been recorded. Deciduous forest and fruit trees are often denuded, and even garden crops sometimes suffer from the enormous numbers of the caterpillars. Similar conditions now prevail in some sections of Europe, for during the spring of 1909 thousands of seedling trees, badly infested with the webs of this insect, were shipped to this country from nurseries in France.

Mr. H. L. Frost, of Arlington, Mass., informed the writers that while in Germany during the summer of 1909 he found that the Thiergarten in Berlin, a large park, had been closed to the public owing to the large numbers of larvæ of the insect which were defoliating the trees. The action of the officials in closing this park was in part due to the serious poisoning of people as a result of coming in contact with caterpillars while visiting the grounds.

Dr. L. O. Howard, Chief of the Bureau of Entomology of this Department, states that he observed this insect present in injurious numbers in certain sections of Europe, particularly in France, during the summer of 1909.

LIFE HISTORY OF THE BROWN-TAIL MOTH.

THE EGGS.

(Pl. IV, fig. 4.)

The female brown-tail moth deposits her eggs in a single elongated cluster on the underside of a leaf, usually near the end of a twig, covering it with brown hair from the end of her body. Each cluster is about two-thirds of an inch long and contains from 200 to 400 eggs which are nearly globular, and yellow. The eggs are deposited during the first three weeks in July, and hatching takes place in from 15 to 20 days.

THE LARVÆ.

(Pl. IV, fig. 5.)

After hatching the young larvæ begin feeding on the epidermis of the leaf on which the egg cluster was deposited and later attack others near by. They are gregarious and usually feed on the terminal leaves of the twigs, which are drawn together and held in position

by silk spun by the caterpillars. As the season advances more leaves are drawn into the web, and this is lined with silk and serves during the winter as a hibernaculum for the larvæ. The caterpillars do not remain in a single large cell. The web is divided by cross partitions into small pockets in each of which one or more of the larvæ remain during the winter. The webs (fig. 4) are very conspicuous on the trees during the winter, as they are usually located at the tips of the branches. (See fig. 5.) During the first warm days of spring the caterpillars come forth from the webs and begin feeding on the bursting buds. In cases where the trees are badly infested the tiny leaves are devoured as fast as they develop. The caterpillars feed until about the 20th of June before becoming full grown. They molt four or five times in the spring, and when ready

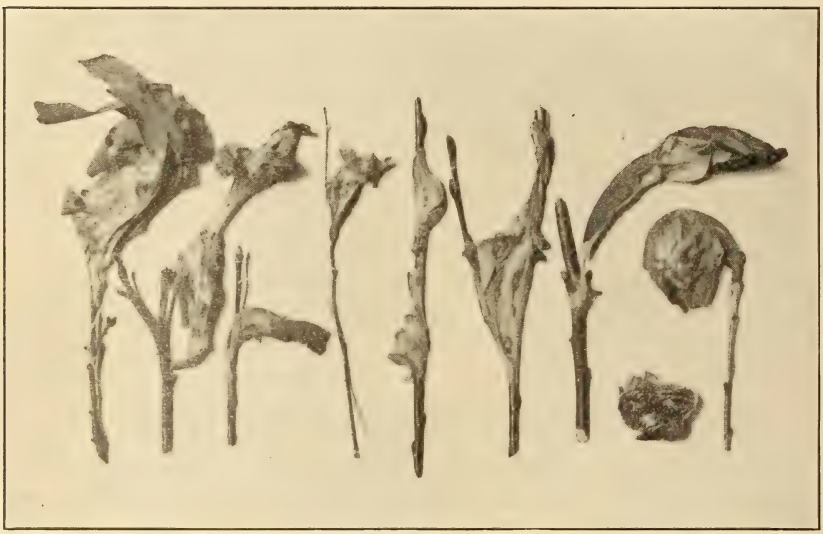
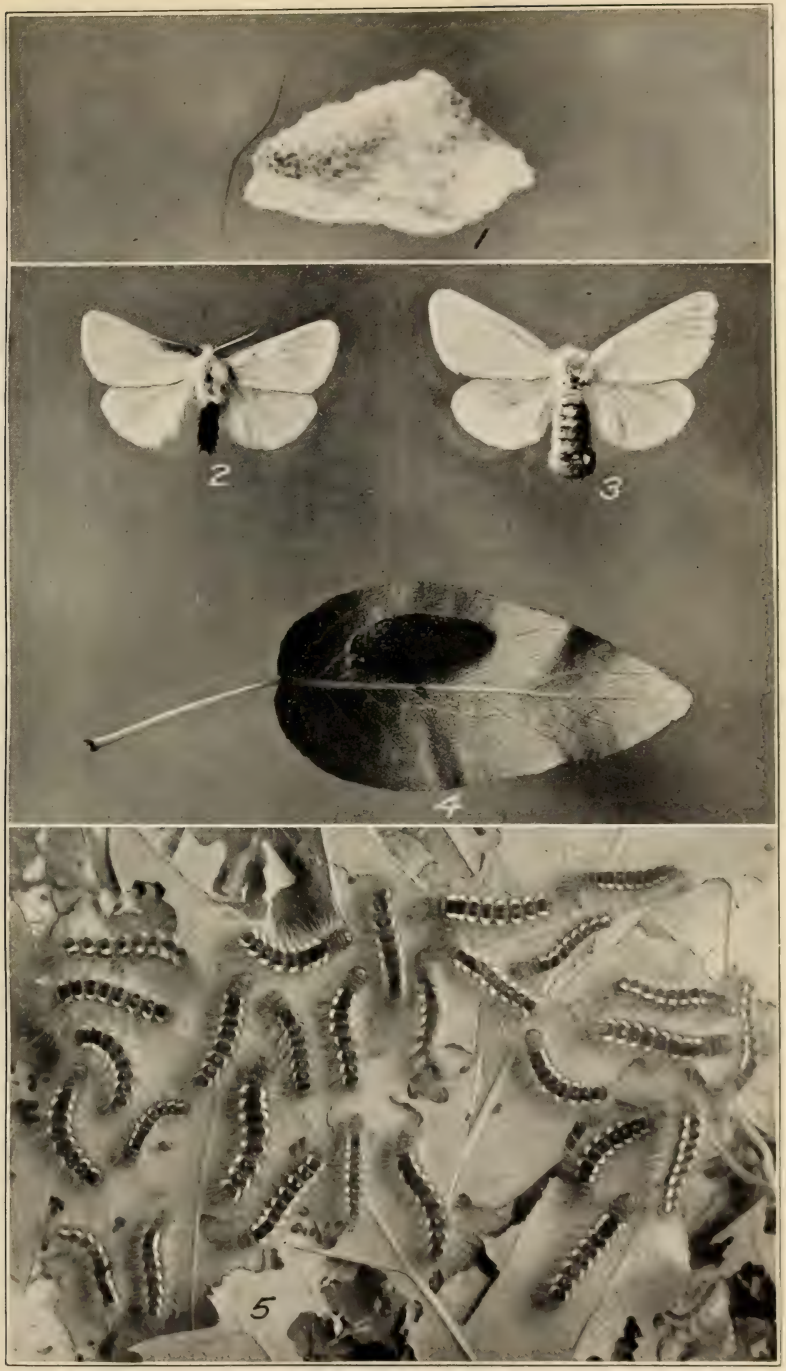


FIG. 4.—Winter webs of the brown-tail moth (*Euproctis chrysorrhœa*). (Original.)

to spin their cocoons are about an inch and a half in length. The body is nearly black and covered with rows of yellow spines and barbed hairs which arise in tufts on the back and sides. There is also a row of nearly white tufts on the full-grown larvæ, which arise along each side of the dorsal abdominal segments. The next to the last two segments each bear a small coral-red tubercle on the dorsal part. As soon as the caterpillars are full-fed they seek shelter and spin up loose cocoons, within which they pupate.

THE PUPÆ.

The cocoons (Pl. IV, fig. 1) may often be found in leaves which have been webbed together by the larvæ, in crevices in the bark,



THE BROWN-TAIL MOTH (EUPROCTIS CHRYSORRHŒA).

Fig. 1.—Cocoon. Fig. 2.—Male moth. Fig. 3.—Female moth. Fig. 4.—Egg cluster on leaf. Fig. 5.—Caterpillars on leaf. (Original.)

under burlaps, beneath the clapboards or under the eaves of houses, or in any situation which affords reasonable shelter. As a rule the cocoons will be found in masses, and, as the silk with which they are constructed is interwoven with hairs from the bodies of the caterpillars, severe poisoning may result in removing them from their resting places. The pupal stage lasts about 20 days, most of the moths emerging during the first 10 days in July. Weather conditions during the spring serve to accelerate or retard the growth of the caterpillars, so that the time of pupation and emergence of the moths varies considerably.

THE ADULTS.

(Pl. IV, figs. 2, 3.)

Both males and females are white and bear a tuft of yellowish-brown hairs at the end of the abdomen, from which the name "brown-tail moth" is derived. Although the abdomen of the female is much larger than that of the male, the female of the brown-tail moth, unlike that of the gipsy moth, is capable of strong flight, and the spread of the species is therefore not handicapped as in the case of the latter species. Both sexes fly more frequently at night than in the daytime, although most of the eggs are deposited during the day. The moths are attracted to strong light, especially electric arc lights in cities and towns, and during the nights when the moths are most abundant the areas around these lights sometimes have the general appearance of a heavy snowfall, due to the great number of flying insects. Stores and houses in the neighborhood are often invaded by the moths, and several cases are on record where merchants have been obliged to close their stores during the height of a moth flight in order to prevent annoyance and trouble caused by the enormous num-

FIG. 5.—Oak tree in winter, showing webs of the brown-tail moth at tips of branches. (Original.)

bers of these insects. The morning following a flight, the houses, telephone poles, and trees in the immediate vicinity of the arc lights are usually well covered with small white moths (see fig. 6); and it is no uncommon thing for lamp trimmers to collect one or two quarts of dead moths inside the globe surrounding a light. The hairs from the abdomens of the moths are poisonous, as well as those from the caterpillars, and a great many persons have been caused severe inconvenience by coming in contact with the adult insects.

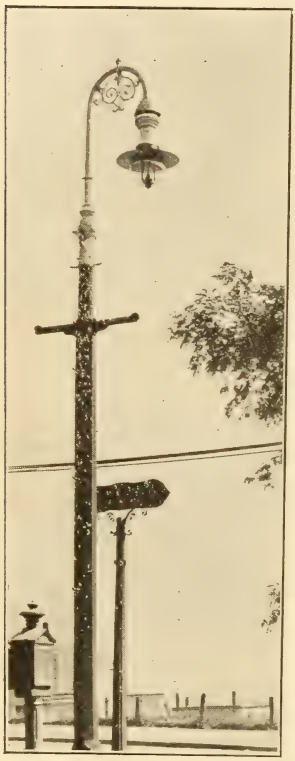


FIG. 6.—Brown-tail moths on electric light pole, Somerville, Mass., July 2, 1908. (From Kirkland.)

The moths' habit of flying to lights serves to increase their distribution, especially in the more thickly populated regions.

Large numbers of the insects are killed, however, by coming in contact with the light and many of the survivors are destroyed by birds the morning following the flight. The English sparrow has been observed by Mr. Kirkland to kill large numbers of the moths which remained about the lamps by pulling off the wings and devouring the bodies.

POISONING EFFECT OF BROWN-TAIL HAIRS.

From the time this insect was first found in Somerville numerous reports were received that the caterpillars were poisonous to human beings. Many people were severely affected with what was termed "the brown-tail rash," and much complaint arose on that account.

The best explanation of the trouble was that the barbed hairs of the caterpillars (fig. 7), when they came in contact with human skin, caused severe irritation. The scratching to relieve this itching forced the hairs farther into the tissue, which resulted in a slight swelling and an intense burning and stinging sensation.

When the housewife swept the caterpillars from the porch or brushed down the cocoons, which are interlaced with larval hairs, many were broken, and as a result severe cases of brown-tail rash followed.

The moths are provided with these barbed hairs, but to a less extent than the larvæ, and cases of poisoning have been reported during the flight of moths in the summer.

Broken hairs which float in the air when the caterpillars, webs, or cocoons are disturbed also cause severe internal irritation and poisoning if the dust is inhaled or swallowed in any considerable quan-

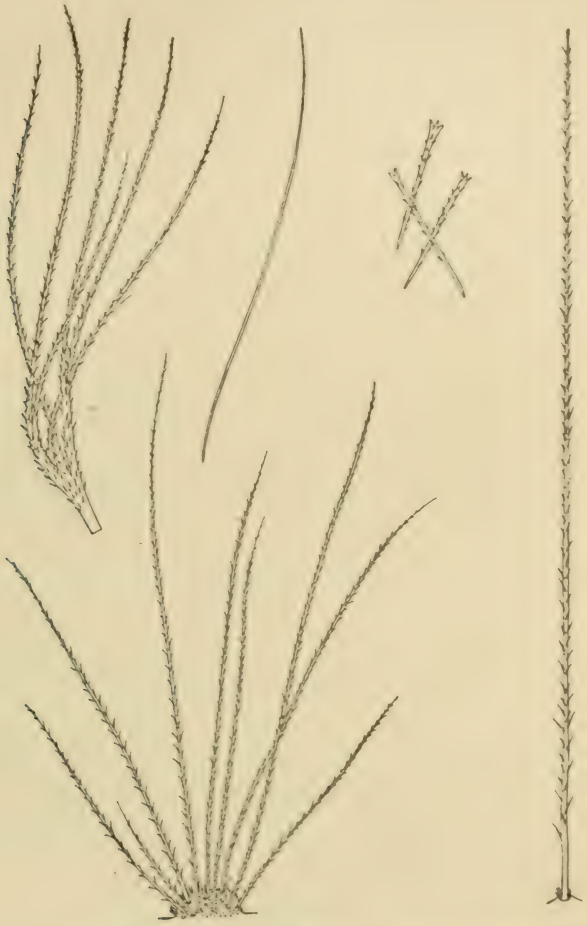


FIG. 7.—Hairs of the caterpillar of the brown-tail moth, highly magnified. (Adapted from Kirkland.)

tities. The poisoning has caused very serious illness to men engaged in the work against the moths, in the field, and at the Parasite Laboratory, and each year many are obliged to seek other employment, and not a few have been under a physician's care. The death of one man was due to severe internal poisoning contracted while employed on the work, particularly while turning burlaps.

Underclothes and bedding should not be put out upon the line during the caterpillar season, as the floating hairs may alight on such articles, which, when used, may result in serious poisoning.

During the year 1906 a careful study of this dermatitis was made by Dr. E. E. Tyzzer, of the Harvard Medical School, and a report was published by him.[a]

He concludes from his investigation that the barbed hairs not only cause a mechanical irritation but that they contain a poison which acts directly on the corpuscles of the blood. This results in a breaking down of the corpuscles to a certain extent and in their assuming a jagged outline instead of a circular one.

Such a multitude of people have suffered from this form of poisoning that many remedies have been prepared and sold which are warranted to give relief. During the summer metropolitan newspapers and many of the smaller papers in New England contain advertisements of remedies for the brown-tail rash. The trouble is more serious during hot weather, when persons are perspiring freely, and the skin at this time seems less resistant to the entrance of the spines.

Some of the advertised remedies give a certain measure of relief, but none of the remedies suggested is wholly efficacious. Applications which are cooling to the skin, such as witch-hazel or alcohol, serve to allay the irritation to some extent and reduce the suffering caused by the poison.

The internal irritation which is caused by breathing or swallowing the poisonous hairs is often very serious and no effective remedy has been found.

NATURAL ENEMIES OF THE GIPSY AND BROWN-TAIL MOTHS NATIVE TO AMERICA.

Aside from the experimental work on insecticides and a careful, detailed study of all phases of the life history and habits of the gipsy and brown-tail moths, considerable time was devoted by the Massachusetts authorities to an investigation of the native natural enemies which attack them in the field.

Both species are partially controlled in Europe by parasites and predaceous enemies, and it was desirable to ascertain if the closely related beneficial species in this country were showing any marked tendency toward controlling the pests.

Field observations on birds were made by Mr. Forbush, who was ably assisted in this work by Messrs. J. A. Farley and F. H. Mosher, the late Charles E. Bailey, and numerous other careful observers. A large number of native insectivorous birds were found feeding on

[a] In Second Annual Report of the Superintendent for Suppressing the Gypsy and the Brown-tail Moths, Boston, 1907, pp. 154–168.

the gipsy moth. Many of the observations have been published in the report by Forbush and Fernald already cited.

Unfortunately, conditions in the territory infested were not very favorable to the increase of insectivorous birds, and this, of course, served to limit their activities and usefulness. A few species, among which may be mentioned the crow, while destroying many of the larvæ, undoubtedly aided the spread of the gipsy moth by dropping live caterpillars in uninfested sections.

Field observations were made and work in rearing the insect enemies of these moths was carried on by Messrs. A. H. Kirkland, A. F. Burgess, F. H. Mosher, and others.

A few species of hymenopterous and dipterous parasites were found working in the field and small numbers of the adults were reared at the insectary. Among the predaceous enemies were several species of beetles (Carabidæ) and stink bugs (Pentatomidæ) which were found feeding on the larvæ in the field and were studied in detail in the laboratory.

Although not an insect, the common toad should be mentioned as doing valuable work in destroying such specimens of the insects as came within its reach.

The rapid development and unprecedented injury caused by the gipsy moth after the state work was abandoned show conclusively that native natural enemies are entirely unable to cope with the situation.

PROGRESS OF THE STATE WORK IN MASSACHUSETTS, 1890–1900.

The administration of any extensive public work almost invariably arouses more or less antagonism, and the gipsy moth work was no exception in this respect. In compliance with the provisions of the law which provided for the extermination of this insect, no effort was made to introduce its parasites or natural enemies from abroad, as it would have been necessary to allow extensive colonies of the insect to remain untreated in order to give introduced parasites an opportunity to become established. Some criticism was occasioned by this manner of handling the work and in addition to this many property owners in sections of the State which were not infested failed to see the necessity for making large appropriations to destroy the insect. Active opposition developed in some sections of the infested territory, which was occasioned by ignorance as to the methods of carrying on the work.

Realizing that the work was of a different character from any that had been attempted previously, and that new methods and devices must be employed to handle the problem with any degree of success, great effort was made to test in a practical way any suggestions that

seemed to have a bearing on reducing the expense of making the work more effective.

From the time the first state appropriation was made until the close of the work the gipsy moth committee procured expert opinions from the leading entomologists of the country, and during this period a large number of prominent scientists visited the territory, inspected the work, and without exception reported that the extermination of the gipsy moth was not only practicable but feasible and that it could be accomplished provided proper financial support was given the work. In the winter of 1894–1895 an unsuccessful attempt was made to secure national aid in exterminating this insect. A bill, carrying an appropriation for $40,000, was passed by the United States Senate, but it was defeated in the conference committee. During the session of Congress, 1896–1897, an appropriation was made for an investigation of the ravages of the gipsy moth in this country. Dr. L. O. Howard, Chief of the Bureau of Entomology, made several visits to the infested territory and thoroughly examined the conditions and the work which was being done. Mr. C. L. Marlatt, first assistant entomologist, also made a visit to the infested district and investigated the condition of the territory. The report of Doctor Howard[a] highly commended the work which had been done and stated his opinion that the extermination of the gipsy moth could be accomplished. During the winter of 1897 the Massachusetts Society for the Promotion of Agriculture secured the services of Dr. John B. Smith, state entomologist of New Jersey, to investigate the work and report the conditions found. The report strongly favored continuing the work and expressed the opinion that the insect could be exterminated if sufficient funds were appropriated, but the society did not publish the report in full. The condition of the infested territory continued to improve. The residential sections were in excellent condition in 1899, although small numbers of the insect were present. Many woodland colonies had been entirely exterminated, as evidenced by the fact that none of the insects had been found for three successive years. The spread of the brown-tail moth, however, continued each year and little hope was entertained of being able to exterminate it.

DISCONTINUANCE OF THE STATE WORK IN MASSACHUSETTS.

At the annual session of the legislature in the winter of 1900 a special committee was appointed to investigate the gipsy-moth work. After numerous hearings it was reported that the insect need not be considered a serious pest, and further that "we find no substantial proof that garden crops or woodlands have suffered serious or lasting

[a] Bul. 11, n. s., Division of Entomology, U. S. Dept. of Agriculture.

injury or are likely, with that precaution or oversight which prudent owners are disposed to give their own interests, to be subjected to that devastation which one would have the right to anticipate from these reports. It appears to us that the fears of the farmers throughout the State have been unnecessarily and unwarrantably aroused, evidently for the purpose of securing the effect of those fears upon the matter of annual appropriations * * * We do not share these exaggerated fears and the prophesies of the devastation and ruin are unwarranted and in the most charitable view are but the fallacies of honest enthusiasts." As a result of the report of this committee no further appropriation was made for carrying on the work. The tools and equipment which had been used were ordered sold, and the insect was allowed to develop without restriction.

CONDITIONS IN THE INFESTED TERRITORY AT THE CLOSE OF THE STATE WORK.

As before stated, the area found infested in 1891 included 30 towns and cities, covering 200 square miles. Between the years 1891 and 1900 isolated colonies were discovered beyond these limits in Brookline, Burlington, Danvers, Georgetown, Manchester, Newton, and Lincoln. These infestations were given special attention and several of them were practically exterminated before the work was discontinued. Vigorous measures were enforced over the entire infested territory and all of the worst colonies, including those in the woodlands, had been reduced to such an extent that the extermination of the insect was practically assured. Several towns had been completely cleared of the insect, and the residential sections showed no defoliation, and considerable search was necessary for a nonexpert to secure specimens of the insect.

FUNDS EXPENDED BY THE STATE DURING THE PROGRESS OF THE WORK.

During the progress of the work the following amounts were asked for and received for the suppression of the pest:

Year.	Amount asked.	Amount appropriated.
1890	$50,000	$50,000
1891	50,000	50,000
1892	75,000	75,000
1893	165,000	100,000
1894	165,000	100,000
1895	200,000	150,000
1896	200,000	100,000
1897	200,000	150,000
1898	200,000	200,000
1899	200,000	200,000
1900	200,000	
Total expenditure		1,175,000

RESULTS OF DISCONTINUANCE OF THE WORK.

During the years 1900 and 1901 little notable injury was caused by the gipsy moth and little attention was paid to it.

In the winter of 1902 a small pamphlet was issued by the state board of agriculture setting forth the fact that the moth was increasing to an alarming extent in many of the wooded districts and predicting that unless all signs failed enormous injury would result. Mention was also made of the fact that about 4 square miles had been found infested in Providence, R. I., during the summer of 1901. This was the first infestation found outside the State of Massachusetts, and from its location it was believed that the insects had been purposely liberated by some malicious person.

At this time the brown-tail moth had spread rapidly in a northeast direction throughout eastern Massachusetts and into New Hampshire and Maine. Already many persons were being poisoned severely by the caterpillars, especially in the sections around Boston, where the moths were becoming abundant.

During the next two years the gipsy moth increased to such an extent that thousands of acres of woodland were defoliated. The caterpillars appeared in such swarms as to denude the orchards and ornamental trees in most of the sections which were previously infested. Large areas of pine timber died as a result of the work of the pest, and real estate values rapidly depreciated in the worst infested sections.

Valuable shade trees were killed outright or injured to such an extent that they had to be cut down, owing to their unsightly appearance.

The caterpillars swarmed into the houses, covered fences, and spun down from the trees upon the clothing of pedestrians, so that they became an unbearable nuisance. Some of them fell upon teams or automobiles and were carried long distances and served to establish new colonies. Stories of the immense numbers of caterpillars seem almost incredible. On several occasions trolley cars were prevented from running until the tracks were cleared of the crushed and swarming insects. The following spring it was necessary for many of the motormen to wear veils to keep their eyes and faces free from the caterpillars which swarmed from the trees. Acres of forest died as the result of the ravages of the caterpillars, the injury including both hardwood trees and conifers. In fact, the conditions which existed in Medford in 1890 were very mild compared with those in the area infested in 1904. To make matters worse, the brown-tail moth appeared at this time in alarming numbers. Thousands of persons were poisoned by the hairs of this insect, and young children especially suffered severely. Physicians reported many cases of this

kind, and general appeal was made that something be done to abate the nuisance.

During the summer of 1904, Mr. C. L. Marlatt, first assistant entomologist of this Bureau, visited the infested territory and strongly urged that the matter be given immediate attention. In his report on the conditions existing, which has been published in Circular 58, Bureau of Entomology, he stated that at the time his observations were made the property owners in the badly infested section were at a conservative estimate spending more than $200,000 annually in fighting the gipsy moth, and that the results were far from satisfactory owing to the fact that the work was not carried on in a systematic manner. The amount cited represents the largest annual appropriation which had been made by the State before the work was discontinued.

All these factors led to the formation of many local associations which had for their object the destruction of the moths. Many of the infested towns and cities appropriated funds which were used to protect the trees, and the citizens, after becoming thoroughly aroused, fought the pests vigorously as a matter of self-protection. The work, however, was far from effective because it was not properly organized and undertaken in a systematic manner, and while many owners had their premises well taken care of, their efforts were largely nullified by the negligence of careless neighbors or nonresident property owners. This was particularly true on estates adjoining wooded areas which had a small market value.

The brown-tail moth, which had confined most of its energies up to the present time to feeding on fruit and ornamental trees, was now found widely scattered throughout the woodlands, and the trees, especially oaks, in many regions were thoroughly infested with webs of the pest.

STATE WORK RESUMED IN MASSACHUSETTS.

So serious was the situation and so urgent were the appeals for assistance that the Massachusetts legislature took action in the matter in 1905. The law was amended in 1906 and is given in full, as it has formed the basis for similar laws in other States.

[Chap. 381, acts of 1905, as amended by chap. 268, acts of 1906.]

AN ACT To provide for suppressing the gypsy and brown tail moths.

Be it enacted, etc., as follows:

SECTION 1. For the purposes of this act the pupæ, nests, eggs, and caterpillars of the gypsy and brown tail moths and said moths are hereby declared public nuisances, and their suppression is authorized and required; but no owner or occupant of an estate infested by such nuisance shall by reason thereof be liable to an action, civil or criminal, except to the extent and in the manner and form herein set forth.

SEC. 2. The governor, by and with the consent of the council, shall appoint a superintendent for suppressing the gypsy and brown tail moths and shall determine his

salary. The governor may, with the consent of the council, remove said superintendent at any time for such cause as he shall deem sufficient. In case of the death, removal, or resignation of the superintendent the governor shall forthwith appoint a successor. On or before the third Wednesday in January in each year the superintendent shall make a report of his proceedings to the general court, which shall be a public document and shall be printed. Said report shall separate so far as is practicable the expenditures on work against the gypsy moth from those on work against the brown tail moth in each city and town.

Sec. 3. [As amended by section 1, chapter 268, acts of 1906.] The said superintendent shall act for the Commonwealth in suppressing said moths as public nuisances, in accordance with the provisions of this act. For this purpose he shall establish an office and keep a record of his doings and of his receipts and expenditures, and may, subject to the approval of the governor, make rules and regulations governing all operations by cities, towns or individuals under this act. He may employ such clerks, assistants and agents, including expert advisers and inspectors, as he may deem necessary and as shall be approved by the governor. He may make contracts on behalf of the Commonwealth; may act in cooperation with any person, persons, corporation, or corporations, including other States, the United States, or foreign governments; may conduct investigations and accumulate and distribute information concerning said moths; may devise, use and require all other lawful means of suppressing or preventing said moths; may lease real estate when he deems it necessary, and, with the approval of the board in charge, may use any real or personal property of the Commonwealth; may at all times enter upon the land of the Commonwealth or of a municipality, corporation, or other owner or owners, and may use all reasonable means in carrying out the purposes of this act; and, in the undertakings aforesaid, may, in accordance with the provisions of this act, expend the funds appropriated or donated therefor; but no expenditure shall be made or liability incurred in excess of such appropriations and donations.

Sec. 4. [As amended by section 2, chapter 268, acts of 1906.] Cities and towns by such public officer or board as they shall designate or appoint, shall, under the advice and general direction of said superintendent, destroy the eggs, caterpillars, pupæ, and nests of the gypsy and brown tail moths within their limits, except in parks and other property under the control of the Commonwealth, and except in private property, save as otherwise provided herein. When any city or town shall have expended within its limits city or town funds to an amount in excess of five thousand dollars in any one calendar year, in suppressing gypsy or brown tail moths, the Commonwealth shall reimburse such city or town to the extent of fifty per cent of such excess above said five thousand dollars.

Cities or towns, where one twenty-fifth of one per cent of the assessed valuation of real and personal property is less than five thousand dollars, and where the assessed valuation of real and personal property is greater than six million dollars, shall be reimbursed by the Commonwealth to the extent of eighty per cent of the amount expended by such cities or towns of city or town funds in suppressing the gypsy and brown tail moths in any one calendar year, in excess of said one twenty-fifth of one per cent.

In the case of towns where the assessed valuation of real and personal property is less than six million dollars, after they have expended in any one calendar year town funds to an amount equal to one twenty-fifth of one per cent of their assessed valuation of real and personal property, the Commonwealth shall expend within the limits of such towns, for the purpose of suppressing the gypsy and brown tail moths, such an amount in addition as the superintendent with the advice and consent of the governor shall recommend. Disbursements made by said last named towns in excess of said one twenty-fifth of one per cent shall be reimbursed by the Commonwealth every sixty

days; but in the case of all others the Commonwealth shall reimburse cities and towns annually according to the provisions of this act.

No city or town shall be entitled to any reimbursement from the Commonwealth until it has submitted to the auditor of the Commonwealth itemized accounts and vouchers showing the definite amount expended by it for the purpose of this act; nor shall any money be paid out of the treasury of the Commonwealth to cities or towns, pursuant to the provisions of this act, until said vouchers and accounts have been approved by the superintendent and the auditor of the Commonwealth.

For the purposes of this section the years nineteen hundred and five and nineteen hundred and seven shall be considered half years, and the valuation for the year nineteen hundred and four shall be taken as a basis.

SEC. 5. [As amended by section 3, chapter 268, acts of 1906.] When, in the opinion of the superintendent, any city or town is not expending a sufficient amount for the abatement of said nuisance, or is not conducting the necessary work in a proper manner, then the superintendent shall, with the advice and consent of the governor, order such city or town to expend such an amount as the superintendent shall deem necessary, and in accordance with such methods as the superintendent, with the consent of the governor, shall prescribe: *Provided*, That no city or town where the assessed valuation of real and personal property exceeds six million dollars shall be required to expend, exclusive of any reimbursement received from the Commonwealth, during any one full year more than one fifteenth of one per cent of such valuation, and that no town where the assessed valuation of real and personal property is less than six million dollars shall be required to expend, exclusive of any reimbursement received from the Commonwealth, during any one full year more than one twenty-fifth of one per cent of such valuation. For the purposes of this section the valuation of the year nineteen hundred and four shall be used.

Any city or town failing to comply with the directions of the said superintendent in the performance of said work within the date specified by him shall pay a fine of one hundred dollars a day for failure so to do; said fine to be collected by information brought by the attorney-general in the supreme judicial court for Suffolk County.

SEC. 6. [As amended by section 4, chapter 268, acts of 1906.] The mayor of every city and the selectmen of every town shall, on or before the first day of November in each year, and at such other times as he or they shall see fit, or as the state superintendent may order, cause a notice to be sent to the owner or owners, so far as can be ascertained, of every parcel of land therein which is infested with said moths; or, if such notification appears to be impracticable, then by posting such notice on said parcels of land, requiring that the eggs, caterpillars, pupæ and nests of said moths shall be destroyed within a time specified in the notice.

When, in the opinion of the mayor or selectmen, the cost of destroying such eggs, caterpillars, pupæ, and nests on lands contiguous and held under one ownership in a city or town shall exceed one half of one per cent of the assessed value of said lands, then a part of said premises on which said eggs, caterpillars, pupæ or nests shall be destroyed may be designated in such notice, and such requirement shall not apply to the remainder of said premises. The mayor or selectmen may designate the manner in which such work shall be done, but all work done under this section shall be subject to the approval of the state superintendent.

If the owner or owners shall fail to destroy such eggs, caterpillars, pupæ or nests in accordance with the requirements of the said notice, then the city or town, acting by the public officer or board of such city or town designated or appointed as aforesaid, shall, subject to the approval of the said superintendent, destroy the same, and the amount actually expended thereon, not exceeding one half of one per cent of the assessed valuation of said lands, as heretofore specified in this section, shall be assessed

upon the said lands; and such an amount in addition as shall be required shall be apportioned between the city or town and the Commonwealth in accordance with the provisions of section four of this act. The amounts to be assessed upon private estates as herein provided shall be assessed and collected, and shall be a lien on said estates, in the same manner and with the same effect as is provided in the case of assessments for street watering.

Sec. 7. [As amended by section 5, chapter 268, acts of 1906.] If, in the opinion of the assessors of a city or town, any land therein has received, by reason of the abatement of said nuisances thereon by said superintendent or by said city or town, a special benefit beyond the general advantage to all land in the city or town, then the said assessors shall determine the value of such special benefit and shall assess the amount thereof upon said land: *Provided*, That no such assessment on lands contiguous and held under one ownership shall exceed one half of one per cent of the assessed valuation of said lands; and *Provided*, That the owner or owners shall have deducted from such assessment the amount paid and expended by them during the twelve months last preceding the date of such assessment toward abating the said nuisances on said lands, if, in the opinion of the assessors, such amount has been expended in good faith. Such assessment shall be a lien upon the land for three years from the first day of January next after the assessment has been made, and shall be collected under a warrant of the assessors to the collector of taxes of such city or town, in the manner and upon the terms and conditions and in the exercise of the powers and duties, so far as they may be applicable, prescribed by chapter thirteen of the Revised Laws relative to the collection of taxes.

Real estate sold hereunder may be redeemed within the time, in the manner, and under the provisions of law, so far as they may be applicable, set forth in chapter thirteen of the Revised Laws for the redemption of land sold for taxes.

A person aggrieved by such assessment may appeal to the superior court for the county in which the land lies, by entering a complaint in said court within thirty days after he has had actual notice of the assessment, which complaint shall be determined as other causes by the court without a jury. The complaint shall be heard at the first sitting of said court for trials without a jury after its entry; but the court may allow further time, or may advance the case for speedy trial, or may appoint an auditor as in other cases. The court may revise the assessment, may allow the recovery back of an amount wrongfully assessed which has been paid, may set aside, in a suit begun within three years from the date thereof, a collector's sale made under an erroneous assessment, may award costs to either party and may render such judgment as justice and equity require.

If, in the opinion of the assessors, the owner of an estate upon which an assessment as aforesaid has been made is, by reason of age, infirmity or poverty unable to pay the assessment, they may upon application abate the same. Every city or town in rendering an account to the state auditor as provided for in section four of this act shall deduct from such amount as it has expended the total amount it has received for work performed under section six of this act during the term covered by the account: *Provided*, Such work was performed under such conditions as require reimbursement in whole or in part by the state.

Sec. 8. To meet the expenses incurred under authority of this act, there shall be allowed and paid out of the treasury of the Commonwealth, during the period up to and including May first, nineteen hundred and seven, the sum of three hundred thousand dollars. Of this amount seventy-five thousand dollars may be expended during the calendar year nineteen hundred and five; one hundred and fifty thousand dollars, and any unexpended balance of the previous year, may be expended during the calendar year nineteen hundred and six; and seventy-five thousand dollars, and any unexpended balance of the previous years, may be expended during the calendar year nineteen hundred and seven, up to and including May first.

SEC. 9. An additional sum of ten thousand dollars in each of the years nineteen hundred and five, nineteen hundred and six and nineteen hundred and seven may, in the discretion of the state superintendent, be expended by him for experimenting with parasites or natural enemies for destroying said moths, and any unexpended balance of any year may be expended in the subsequent years.

SEC. 10. Chapter two hundred and ten of the acts of the year eighteen hundred and ninety-one and sections one and two of chapter five hundred and forty-four of the acts of the year eighteen hundred and ninety-eight and section two of chapter fifty-seven of the acts of the year nineteen hundred and two, are hereby repealed.

SEC. 11. [As amended by section 6, chapter 268, acts of 1906.] A person who willfully resists or obstructs the superintendent or an official of a city or town, or a servant or agent duly employed by said superintendent or by any of said officials, while lawfully engaged in the execution of the purposes of this act, or who knowingly fails to comply with any of the rules or regulations issued by said superintendent, shall forfeit a sum not exceeding twenty-five dollars for each offence.

SEC. 12. Valuations of real and personal property of the year nineteen hundred and four shall govern the provisions of this act.

SEC. 13. This act shall take effect upon its passage.

Approved May 8, 1905.

This law is now in force, with a few minor administrative amendments. In the spring of 1909, following the resignation of the state superintendent, an amendment was enacted placing the work in charge of the state forester.

The law provides a cooperative plan for fighting the gipsy moth and brown-tail moth by which each infested city or town is required to appoint a local superintendent and to expend annually a certain amount, based on its valuation, and, after this has been done, subject to the approval of the state forester, reimbursement is allowed by the State in amounts graduated according to assessed valuation. Thus the large cities are required to expend a larger amount before receiving any reimbursement from the State, and then receive a smaller percentage than the towns with small valuations and large areas of woodland, which are very expensive to treat.

Cities and towns with an assessed valuation on real and personal property of $12,500,000 or more shall, after expending $5,000 in any one year, be reimbursed 50 per cent of all further expenditures.

Cities and towns where the assessed valuation ranges between $6,000,000 and $12,500,000, after expending one twenty-fifth of 1 per cent of the valuation, are reimbursed 80 per cent of all further expenditures.

Cities and towns where the assessed valuation falls below $6,000,000 are required to expend one twenty-fifth of 1 per cent and are reimbursed in full for all further expenditures.

The property owner is required to clear his premises of the insects and to expend therefor not more than one-half of 1 per cent, or $5 per $1,000, of the assessed valuation. In case of failure to do this work after proper notice has been served, the premises may be treated by

the town officials and the cost, not to exceed the above amount, may be levied and collected in taxes.

The whole purport of the law is to divide the burden between the property owner, the infested municipalities, and the State, and to place the entire work under state supervision in order to secure uniformity of methods and economy of expenditure.

The law provided for an appropriation of $75,000 for the year 1905, $150,000 for 1906, and $75,000 for 1907. An appropriation of $10,000 a year was also made for a period of three years to provide for the expense of introducing the parasites and natural enemies of these insects from abroad and for their propagation and dissemination in the infested district. The latter work was organized in cooperation with the United States Bureau of Entomology under the direction of Dr. L. O. Howard, Chief of the Bureau.

On May 15, 1905, Mr. A. H. Kirkland was appointed state superintendent by Hon. W. L. Douglas, then governor of the State. The wisdom of this appointment was soon apparent in the results secured in organizing a most difficult piece of work and in training a skilled force of men for efficient service, and the State was very fortunate in being able to procure the services of a well-trained entomologist, who brought to the work a thorough knowledge of the conditions to be met, high scientific attainments, and rare executive ability—a combination seldom secured.

The work during the year 1905 consisted in organizing the moth forces in towns in the infested territory and sending the most expert men that could be employed by the central office into the outside districts to determine if the gipsy moth was present. As a result of a hurried inspection it was determined that 124 towns, covering an area of 2,224 square miles, were more or less infested, against 34 towns, covering an area of 359 square miles, in which the moth was known to exist in 1900, when the state work was discontinued. The gipsy moth was also found in several towns north of the Massachusetts line in New Hampshire, to and including Portsmouth, while the colony at Providence, R. I., had increased to a considerable extent. Practically the same methods were used as those adopted when the old work was in progress, although, owing to the increased area infested and the extremely bad condition of the central district, it was necessary to abandon the idea of extermination and use all possible methods to control the insect and to prevent its further spread. The scouting operations which were carried on in the outside infested towns were, of course, done in a rather hurried manner on account of the great pressure of other work and the necessity for immediately taking active measures to destroy the moths in the badly infested towns and cities. Much effort was necessary in order to organize the work and secure a trained force of local men.

This large area, which included thousands of acres of badly infested woodland, was in a much worse condition than in 1904 and it soon became evident that heroic measures must be taken and an enormous amount of work done if any appreciable progress was to be made in preventing widespread injury.

A single case will serve as an illustration of the loss to owners of timber caused by the gipsy moth. A tract of woodland near the Bedford and Billerica town line, belonging to the Hosmer estate, was sought by a portable saw mill operator in 1907, who offered $6,000 for the wood and timber, but, as the owners wanted $6,500, the trade was dropped. The following winter, owing to the presence of the moths in large numbers, the lot was sold for about $3,000, and immediately cut, resulting in loss to the owners of at least 50 per cent in one year. At the time the state work ceased in 1900 this property was 4 miles outside of the infested area.

In 1906 the Massachusetts legislature added $150,000 to the appropriation already made for that year and united with the other New England States in an appeal to Congress to furnish aid.

The brown-tail moth was found to be present, in 1905, as far west as central Massachusetts. It also occurred in the southern counties in New Hampshire and along the coast, specimens having been reported from Eastport, Me., and St. John, New Brunswick. A single insect was found at Providence, R. I., during the year.

BEGINNING OF WORK BY THE NATIONAL GOVERNMENT.

The spread of the gipsy and brown-tail moths caused much alarm in the New England States, and in the fall of 1905 an appeal was made to Congress to assist in the work of controlling these pests. The movement was supported by delegations from Maine, where the work of the year had shown that an area of approximately 4,000 square miles was infested with the brown-tail moth and where energetic measures were being taken to control the insect; by New Hampshire, which was seriously infested with both pests; by Massachusetts, where heroic measures were being taken to control the situation; and by Rhode Island, where a serious infestation of the gipsy moth existed.

On December 4, 1905, a bill was introduced by Representative Ernest W. Roberts, of Massachusetts, providing for an appropriation of $250,000, to assist in preventing the spread and securing the control of these pests. The urgent necessity for action was forcibly brought out by a report from Dr. W. E. Britton, state entomologist of Connecticut, in March, 1906, that a few egg clusters of the gipsy moth had been found in Stonington, in that State.

Owing to the fact that approximately 300 square miles was thickly infested in eastern Massachusetts, ample opportunity was offered for

the larvæ to be carried many miles during the early summer, and thus the whole country was in danger of becoming infested.

Later in the season $82,500 was appropriated by Congress. The work was put under the direction of Dr. L. O. Howard, Chief of the Bureau of Entomology, and Mr. D. M. Rogers, then first assistant to state superintendent Kirkland, was appointed special field agent of the Bureau in charge of the field work in New England. This appropriation became available July 1, 1906, and after a conference between the Chief of the Bureau of Entomology, the superintendent of the moth work in Massachusetts, and the special field agent of the Bureau it was decided that the most valuable results could be secured with this appropriation by at once clearing as many roadsides as possible in the thickly infested and much traveled section of Massachusetts. Arrangements were also made to prevent dissemination of the gipsy moth in the outside territory as far as the limited appropriation would allow. A force of 22 men which had been working in the infested district in Rhode Island was carried on the pay roll from July 23, 1906, to May 15, 1907, although the number at the latter date had been reduced to 9 men, so that work in that State could be continued until the state funds were available.

Later in the season scouting parties were organized and a limited amount of work done in the southern parts of New Hampshire and Maine. A more detailed account of this work will be given later in this report.

Owing to the severe infestation in the district around Boston (see Pl. V in comparison with Pl. VI), and to the fact that practically all of the main highways were being used continually during the caterpillar season by automobiles, it seemed necessary to keep the roadsides free from caterpillars if a general dissemination of the pests to distant points was to be prevented. Traffic between Boston and its suburbs, the shore resorts along the coast, and the vacation places in New Hampshire, is particularly heavy during the early summer. At the time of the serious outbreak of the gipsy moth in 1890 the spread of the insect was made possible chiefly by means of teams or carriages that passed through the infested district, and these seldom traveled more than 20 miles in a single day. With the use of the automobile the daily travel often covers a hundred or more miles, so that the danger of spread to remote districts was greatly increased; in fact, recent inspections have shown that the spread of the insect can often be traced directly to this means of conveyance.

A building was rented at Medford at a point within easy reach of the badly infested section where work was to be carried on, the necessary tools and supplies (figs. 8, 9) were installed, and arrangements made for actively beginning the campaign against the moths. Mr. Harry W. Vinton was selected as a special agent to take charge of

WOODLAND AT LEXINGTON, MASS., COMPLETELY DEFOLIATED BY THE GIPSY MOTH.
(ORIGINAL.)

SAME WOODLAND AT LEXINGTON, MASS., AS THAT SHOWN IN PLATE V, THE FOLLOWING YEAR, ILLUSTRATING BENEFICIAL EFFECTS OF CONTROL WORK. (ORIGINAL.)

active operations in the field. Mr. Vinton had served for several years on the gipsy moth work when it was being conducted by the Massachusetts state board of agriculture, and from his long experience and thorough knowledge of the pest and the proper methods of treatment, as well as his familiarity with the infested region, it was possible to begin active operations without delay.

Several trunk roads in Melrose, Saugus, and Wakefield which extended through badly infested woodland were selected, and active cutting operations begun. Crews of men were employed to cut out the brush and worthless trees and to thin the sound timber on a strip 100 feet wide on each side of the highway. The brush was then burned and the egg clusters on the remaining trees and ledges were creosoted. (See fig. 10.) Very little if any work was planned

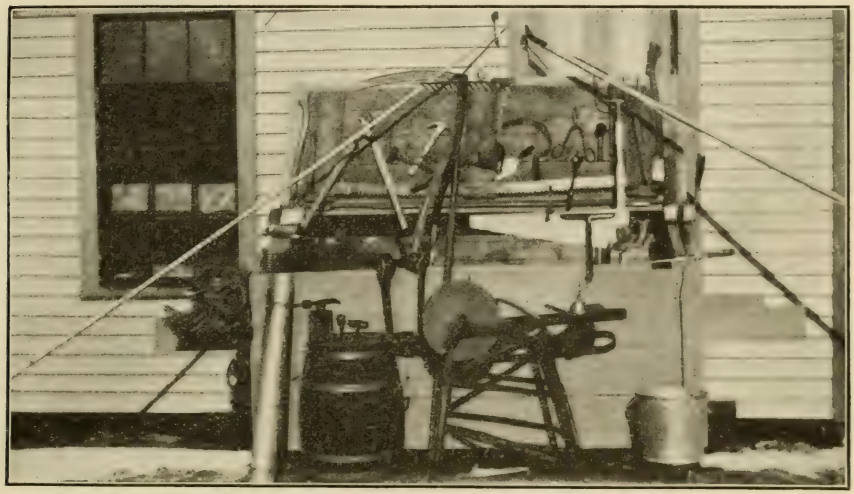


FIG. 8.—Equipment for roadside work against the gipsy moth, used by employees of the Bureau of Entomology. (Original.)

or has been carried out up to the present time in residential parts of the infested district, as the town and city officials, acting under state law, usually keep the trees in such sections fairly free from infestation. The cutting out of these roadways is simply for the purpose of preparing the way for a thorough and economical treatment. It is usually necessary to carefully prune many of the trees in the treated area, and in some cases where they are of special value the cavities in hollow trees are closed with cement, covered with zinc, or sealed with a wooden plug, so that egg clusters can not be deposited in such places, where it is extremely difficult to treat them. In the spring the trees are banded, and burlaps are often used for this purpose. Another method which has come into favor since the gipsy moth work was resumed in Massachusetts is to apply a band

of tanglefoot to the trunks of the trees before the eggs hatch. (See fig. 11.) Rough-bark trees should be scraped where this material is to be placed, so that the surface will be smooth enough to apply the band evenly with a wooden paddle. Care should be taken not to remove the inner bark so that the living wood will be exposed. If the tree tanglefoot can be applied evenly, no scraping should be done. This material will remain sticky for several weeks, and prevent the caterpillars from ascending, but the best practice is to draw a comb through the band as the workman walks around the tree. This brings fresh material to the surface and removes any foreign substances which may have collected. The caterpillars are obliged to feed on what low growth remains on the ground and if this has been well sprayed they are soon destroyed. Aside from the roads

FIG. 9.—Roadside where thinning operations are being carried on, showing tools and equipment used in the work. (Original.)

already mentioned a considerable amount of roadside work was done in the towns of Malden, Lynnfield, Lynn, Peabody, Woburn, Lexington, Burlington, Waltham, and Belmont, and the strips cut out during the fall of 1906 and the spring of 1907 and prepared for spring and summer treatment aggregated about 65 miles. Late in April and early in May, 1907, the trunks of the trees in all these strips were banded with tanglefoot to prevent the caterpillars from climbing the trees, as well as to keep such larvæ as migrated from the woodland back of the strips from destroying the foliage. After the caterpillars hatched the strips were sprayed with arsenate of lead, which was used at the rate of 10 pounds to 100 gallons of water. Previous to this time one small and three large spraying machines operated by gasoline engines had been secured. Owing to the lim-

ited length of time that the insect is in the caterpillar stage it is necessary to provide equipment so that a large area can be thoroughly sprayed in a short time. This renders impracticable the use of hand outfits for such extensive work. The sprayers used had a tank capacity of between 500 and 600 gallons, and it was possible to treat many acres in a single day. Since the work began a number of improvements have been made in spraying outfits used, which have rendered them more efficient and economical. In addition to the spraying the burlap and sticky bands on the trees were examined from time to time and the caterpillars crushed with steel-wire brushes. In the worst infested places it was necessary to go over the strips daily, and even then in some instances it was almost impossible to kill the caterpillars fast enough to prevent some defoliation on the back edge of the treated strips.

FIG. 10.—Employees of the Bureau of Entomology treating egg clusters of the gipsy moth with creosote, using an ordinary paint brush and a brush attached to a long pole. (Original.)

Early in the fall of 1906 a number of the more experienced men were selected and scouting operations were begun in a limited way in Maine, New Hampshire, and Connecticut. (See fig. 12, showing outfit used by gipsy moth scouts.) This work was continued until June, 1907, and a large number of towns were found infested. In the spring of 1907 it became evident that owing to the discovery of so many infested towns, a larger appropriation would be necessary in order to make anything like a careful examination of the outside territory. In May, 1907, Congress appropriated $150,000 for the purpose of carrying on the work, this sum being available for immediate use. Plans were at once made to clear more roadside areas in the worst infested sections and in the fall to scout thoroughly the towns north of the known infested region. Owing to the great increase in the amount of work which was to be taken up, the territory in

Massachusetts was divided into two sections. Mr. Vinton took charge of the crews in one of these sections, and Mr. David G. Murphy was appointed, June 17, to take charge of the crews in the other division. Mr. Murphy, like Mr. Vinton, had had long experience in fighting the gipsy moth in Massachusetts, and had proved by his previous work with the State to be very capable in taking charge of field work. The roadside work was continued in Massachusetts during the summer and fall, and by the next spring the mileage that had been cut out had been increased twofold over that of the previous year. The strips were treated in practically the same manner as already described and much benefit resulted from this work. Special effort was made in the fall to thoroughly scout the region outside of the towns known to be infested in New Hampshire. The work was handicapped to some extent by inability to secure men with sufficient

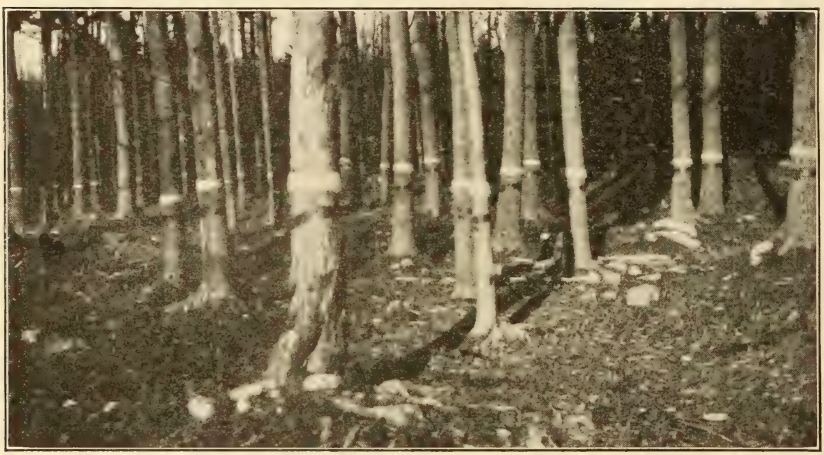


FIG. 11.—Roadside which has been cleared of brush and the trees banded with burlap and tanglefoot. (Original.)

training who were willing to take up this arduous work during the winter. The scouting, however, resulted in the discovery of 17 additional infested towns. Work of a similar character was carried on in Maine, where five more towns were found to be infested.

In the spring of 1908 Congress appropriated $250,000 for the work covering the fiscal year from July 1, 1908, to June 30, 1909. The work of clearing roadsides was vigorously pushed throughout the year so that by the spring of 1909, 170 additional miles of 100-foot strips had been put in good condition for summer treatment. In addition to this amount it was necessary to spray and care for 130 miles of strips that had been thinned during the previous years, so that in the summer of 1909 more than 300 miles of roadside were given careful attention, which undoubtedly prevented many new colonies

from becoming established. Over 200 miles of roadway, not yet cut out, which was more or less infested, was sprayed, and this served to further decrease the danger of dissemination. (See figs. 13 and 14.)

Late in the summer of 1908 plans were made to carry on an extensive inspection of the outside territory in New Hampshire and Maine. Owing to the size of the territory to be covered in New Hampshire it was divided into two sections, and Mr. Irving L. Bailey was selected to take charge of the western section and Mr. Henry L. McIntyre was placed in charge of the work in the eastern section. Both were men of extended experience in gipsy-moth work in the field, Mr. Bailey having been employed as an inspector when the insect was being fought by the Massachusetts state board of agriculture, and Mr. McIntyre having had much practical experience in town work for controlling the moths and later in the field work which was being carried on by this office.

About November 1, several crews of the most expert men were sent to New Hampshire and from time to time the force was increased until over 100 men were employed in scouting work in the various towns. Practically all of the territory south of Lake Winnepesaukee and a double tier of towns west of the Merrimac River were examined and most of them were found to be more or less infested. In this work all of the roadways, orchards, and private property were inspected; in fact, all trees were examined except the large forest areas. Several crews were detailed to scout along the main highways north of Lake Winnepesaukee, as these form the main routes of travel for summer tourists to the White Mountains. The principal roads from Ossipee to the mountains as far as Bethlehem and Bretton Woods were carefully inspected; also along the roads on the west side of the mountains through the Pemigewasset Valley. No egg clusters were found north of Ossipee on the eastern or above Meredith on the western roads. While this work was being carried on several crews were engaged in making examinations of the territory surrounding the known infested towns in Maine. This region was found to be in much more satisfactory condition than during the previous year. All work that seemed necessary was done in Connecticut and the condition of this territory showed marked improvement.

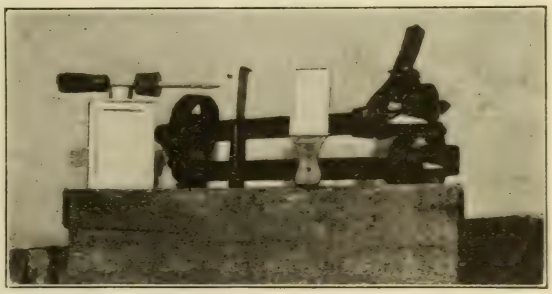


FIG. 12.—Gipsy moth scout's outfit, consisting of climbing irons, mirror, cleaning knife, can of creosote, and brush. (Original.)

The great danger throughout the entire campaign in fighting the gipsy moth has been the existence of large woodland colonies and it has been impossible for either this office, the States, or the individual property owners to keep the moths reduced in territory of this character on account of the vast expense involved. In eastern Massachusetts and southern New Hampshire there are large areas of forest land which are covered with an inferior growth of trees and which are badly infested. In most cases the cost of cleaning up such areas and stamping out the bad colonies would amount to more than the value of the property. This being the case the main attempt has been to keep the roadways through forest areas free from the young caterpillars and to prevent to as great an extent as possible any further spread of the pest. (See Pl. VII.)

FIG. 13.—Roadsides badly infested by the gipsy moth. (Original.)

During February, 1909, Congress appropriated $300,000 to provide for the continuation of the work. This sum was available for the fiscal year beginning July 1, 1909. Since that time work on roadsides has been continued in Massachusetts and up to January 1, 1910, nearly 150 miles of 100-foot strips have been cut out and prepared for spring and summer treatment.

The roadways cut out up to January 1, 1910, aggregate 450 miles of strips. (See fig. 15.) During the period since the government work began about $300,000 has been expended in Massachusetts for labor and transportation of men. This does not include the amounts expended for salaries, rent, tools, equipment, insecticides, supplies, and the expenses that have been paid by the Government for the maintenance of the Gipsy Moth Parasite Laboratory.

Late in October, 1909, 16 scouting crews of 5 men each were sent to the northern portion of the infested district in New Hampshire

VIEW OF WOODLAND NEAR ROADWAY AT WESTON, MASS., SHOWING EFFECT OF CONTROL MEASURES AGAINST THE GIPSY MOTH. (ORIGINAL.)

[On the right is a strip 100 feet wide in which the gipsy moth has been prevented from destroying the foliage and spreading to the road to be distributed by passing vehicles. The trees on the left have been completely defoliated over an area reaching back nearly a mile into the forest. It was necessary to clear the trees from a strip 25 or 30 feet wide in order to protect the treated zone.]

and since that time 5 more crews have been added, making a total of 21 crews, or 105 men, engaged in examining the towns. The first work was taken up in the region surrounding Lake Winnepesaukee and in towns west of the Merrimac River and north of Concord.

January 1, 1910, 41 towns had been scouted and egg clusters were found in 6 towns not previously known to be infested. No egg clusters were found in 6 other towns outside the infested area, and in 4 towns which were found infested and treated last year a careful examination failed to bring to light any egg clusters.

The severe snowstorm and blizzard which prevailed in New England on December 26 resulted in making the roads almost impassable.

FIG. 14.—Same road shown in figure 13, after the completion of thinning operations against the gipsy moth. (Original.)

and coating the trees with snow and ice, and it was necessary to lay off all the scouting crews until weather conditions were suitable to continue the work.

During the season when trees are banded with burlap about 47 men working in Maine were carried on the Bureau of Entomology pay roll, and since that time the number has been increased so that about 60 men engaged in cleaning and scouting have been employed. Small colonies have been found in 3 towns not previously known to be infested. In Rhode Island 53 men were employed during July turning burlap, and on November 21 were transferred from the state pay roll and have been engaged in treating egg clusters and cleaning the trees in the infested territory.

Two men in the employ of the Bureau of Entomology examined the colony at Stonington, Conn., in December and only a single egg cluster was found. A large colony of gipsy moths was found at Wallingford,

Conn., December 14. It was visited by Mr. Rogers, December 20, and arrangements were made with Dr. W. E. Britton, state entomologist of Connecticut, to cooperate in every possible way to stamp out the pest.

The above is a brief outline of the cooperative work which has been carried on by the Bureau of Entomology in suppressing the gipsy moth.

Winter webs of the brown-tail moth have been destroyed whenever they have been found in the belts which are being cleared along the roadways. This insect has spread so rapidly that it has been impossible to carry on an active campaign against it, and in Maine and New

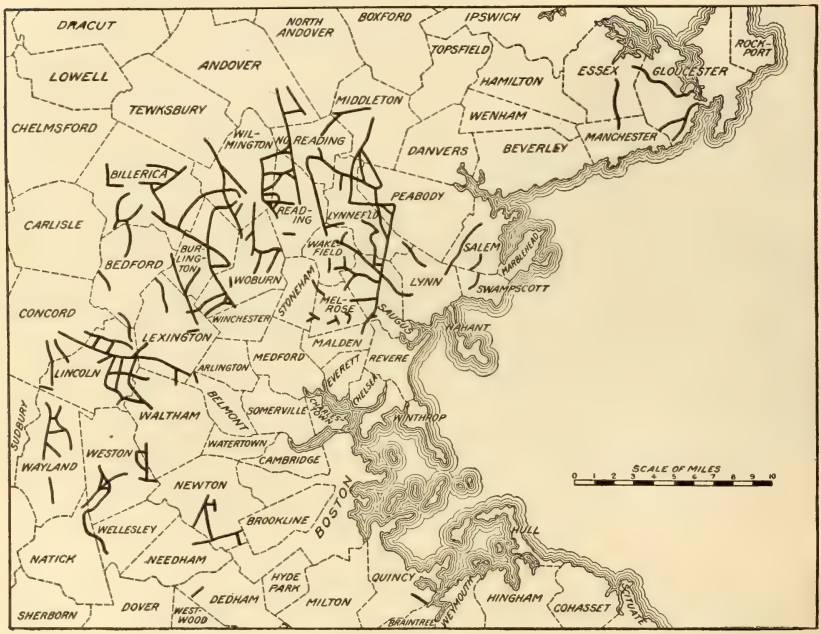


FIG. 15.—Map showing roads in Massachusetts where the brush has been cut, the trees thinned, and those remaining treated by employees of the Bureau of Entomology to prevent the spread of gipsy-moth larvæ on vehicles. (Original.)

Hampshire only a moderate amount of good would have been accomplished if an attempt had been made to destroy the brown-tail webs along the roadways and in the orchards, as the woodlands, especially in the southern part of these States, are very badly infested. In many towns property owners have destroyed the webs found on their orchard and shade trees.

The work of suppressing the gipsy moth is carried on in a different way in each of the New England States. In Massachusetts a large annual appropriation is made by the State, and property owners as well as towns and cities are required to assist in the control of the insect.

The work of the Bureau of Entomology in Massachusetts, therefore, has been practically independent of the state work, except that a hearty spirit of cooperation has always existed between the two offices. In Maine the state appropriations have not been sufficient to finance an active campaign against the insect throughout the year, and a system of cooperation has been established between this office and the Maine department of agriculture, so that the work can be continued uninterruptedly. In New Hampshire, owing to the small appropriations made by the State, the greater part of the work has been carried on by the Bureau of Entomology, the state funds being used for urgent calls which it was impossible for this office to attend to. Practically the same conditions hold in Rhode Island as in Maine, while in Connecticut most of the work has been carried on by the State, and the Bureau of Entomology has furnished only such assistance as was deemed necessary to supplement the local work at Stonington and Wallingford. A summary of the work done in the New England States is given herewith.

WORK BY THE STATE OF MASSACHUSETTS.

During the past five years the State of Massachusetts has appropriated $1,195,000 for the purpose of controlling the gipsy and brown-tail moths, and an additional sum of $75,000 has been expended in an attempt to introduce their parasites and natural enemies. The money has been used, in the main, in reimbursing cities and towns in the infested parts of the State which have expended more than was required by the gipsy moth law. A small part of the appropriation has of course been used for maintenance and supervision of the work, and the central office has adopted a system of inspection of the city and town work in order that uniform standards might be enforced and useless expenditures prevented. The men employed as agents and inspectors by the central office have had long experience in fighting these pests, many of them having served when the work was under the direction of the state board of agriculture.

The amount of money expended by the different cities and towns affected has about equaled that appropriated by the State, while many private property owners and state commissions (such as the Metropolitan Water and Sewage Board and the Metropolitan Park and State Highway Commissions) have expended large sums of money, so that the amount expended annually, exclusive of that spent by the Federal Government, has averaged about $750,000 to $800,000.

The result of the work has been to reduce greatly the infestation in the residential sections. This has not been accomplished, however, without vigorous application of all the best-known methods of fighting the pests. Spraying has been carried on in a wholesale way, and at the present time most of the infested towns have purchased

high-power sprayers, so that a large area of territory can be covered in the short time that the insect is in the larval stage.

In 1909 over 150 high-power and 250 hand spraying outfits were used in the infested district in Massachusetts.

Unfortunately many of the less valuable woodland sections have received little attention, owing to the pressure of more important work. This results each year in large areas being stripped by the caterpillars, great numbers of which die from starvation and disease, and in this way the infestation for the next year or so is materially decreased. Fortunately these badly infested areas are more or less isolated, as strong effort is made to care for the woodland section that is near roads or lines of travel, so that the danger of spread of the insects from these centers of infestation is reduced as much as possible.

It has been impossible, however, up to the present time, owing to the excessive cost, to do all of such work that could be done to advantage. As the residential areas become freer from the insects more funds can doubtless be devoted to this much-needed work.

In addition to the work already outlined a large amount of scouting has been carried on under the direction of the central office and at state expense. This has been done by skilled and experienced men in the towns outside the known infested territory. All the main roads and orchards have been examined in a section several towns deep around the infested area.

Some of the more important and much traveled state roads have been scouted for long distances and this work in 1907 and 1908 resulted in the discovery, near Springfield and Greenfield, Mass., of small colonies of the gipsy moth.

The infestation near Springfield was located near the state road, which is a favorite route for automobiles between Boston and New York City. The outlying colonies discovered in this way have been treated with special care and many of them have been reduced almost to the point of extermination.

The area infested at the present time in Massachusetts is somewhat larger than that which was found in 1905 when the first scouting operations were begun after the work was resumed by the State. This is what would naturally be expected, as it was at that time impossible to undertake scouting operations over such a large territory with the small force of trained men available.

Doubtless many of the colonies since found developed from caterpillars scattered during the time the moth was allowed to spread without restriction, and more colonies will probably be found in the outside territory. Further scouting should be taken up so that these may be discovered at the earliest possible moment and promptly treated.

Much credit is due to the State of Massachusetts for the energetic manner with which this campaign has been waged. The officials at the state office, under the direction of Mr. Kirkland, and later under Mr. L. H. Worthley and State Forester Rane (in whose charge the work was placed by the last legislature), have accomplished excellent results in spite of the many difficulties which had to be met and overcome.

The work undertaken in Beverly, Manchester-by-the-Sea, Gloucester, and Rockport—the region which is known as the north shore of Massachusetts Bay—and also in the towns of Hamilton, Wenham, and Essex deserves special mention. The value of the woodland in this section is probably greater than any other area of the same size in New England, and this fact, together with the magnificent ocean scenery, has resulted in these towns becoming the summer residences of many prominent citizens from all parts of the country. The gipsy moth threatens the destruction of these valuable forests, and as the land is of little agricultural value the towns concerned would shrink thousands of dollars in valuation, and much of the territory would be uninhabitable during the summer season, thus working a double loss to the sections of the State concerned. During the past two years a special fund for carrying on the work has been furnished on the basis of the State supplying one-third, the city of Beverly and the town of Manchester one-third, and the balance being subscribed by the summer residents. In 1909 over $60,000 was expended, the work being carried on by the state forester's office. Over 2,100 acres of woodland have been thinned, sprayed, and protected from moth injury.

Col. Wm. D. Sohier, chairman of the citizens' committee which raised private funds for carrying on the work, in a report recently issued, says:

> It is perfectly evident that had it not been for the work which was done last year and this year conditions on the north shore from Beverly all the way down through Manchester would have been unbearable. All the trees would have been stripped except on a few private estates, and all the pines and hemlocks would have been killed.

Many improvements in methods have been developed while the work has been in progress. Most of these resulted from suggestions made by different members of the state and government forces. A large number of ideas have been tried out in the field to test their utility, and a considerable number of these have been made cooperatively between the state and governmental offices. The whole effort has been to secure the best results by adopting the cheapest possible methods, and practical suggestions have been received with alacrity.

WORK IN THE STATE OF MAINE.

Webs of the brown-tail moth were found at Kittery, Me., in the spring of 1904 by one of the deputy state nursery inspectors of New Hampshire, and Prof. C. M. Weed, who was then entomologist of the New Hampshire agricultural experiment station, informed Hon. A. W. Gilman, commissioner of agriculture of Maine, of the presence of this insect in the latter State. An examination was made at Kittery and in the vicinity by Miss Edith M. Patch, entomologist of the Maine agricultural experiment station, and through the efforts of the above-named officials considerable work was done in the fall of 1904. Many winter webs were collected and burned. Infestations were found not only in Kittery, but at York, Eliot, and other points to the eastward along the coast. Owing to the large territory over which this insect was spread the matter was brought to the attention of the legislature the following winter and an act passed appropriating $5,000 for the year 1905, and $5,000 for the year 1906, for the purpose of controlling the pest. The office of state entomologist was created and placed under the direction of the state commissioner of agriculture, and Prof. E. F. Hitchings, of Waterville, Me., was appointed to take charge of the work. Many of the towns in the infested section voluntarily raised funds to fight the pest, so that a considerable amount in addition to the state appropriation was available for expenditure during the years mentioned.

Owing to the danger of the State becoming infested with the gipsy moth, an appeal for a national appropriation was urged by the State of Maine, in connection with other New England States, and in the fall of 1906 it was possible for this office to send several scouting parties into the section of Maine nearest the infested area in New Hampshire. As a result of this inspection, egg clusters of the gipsy moth were found at Kittery, Eliot, York, South Berwick, Wells, Kennebunk, and Kennebunkport. Several men examined the principal cities and towns east of Portland, but no infestation was found except a single egg cluster discovered by these men on the grounds of the National Soldiers' Home at Togus, Me., which was 81 miles from the nearest known infested locality. Doubtless this infestation was brought about by inmates or visitors unintentionally conveying some of the insects from the infested territory on their clothing or among their personal effects. The work during the year 1906 was continued in Maine with great vigor. The towns found infested showed a generous spirit of cooperation in fighting not only the gipsy moth but the brown-tail moth. The Old York Transcript, in its issue of January 18, 1907, stated that 120,000 brown-tail webs (fig. 16) were burned in a single day. Most of the money expended for collecting these webs was raised by private subscription or appro-

priated by the towns involved. In spite of the vigorous work carried on in the brown-tail moth infested section, the insect continued to spread with marked rapidity and was found in many towns east of the known infested area. In the fall of 1907 scouting parties examined the roadways and orchards throughout the gipsy-moth infested territory. This resulted, as might be expected, in the discovery of several vigorous woodland colonies in Kittery and York. Work was immediately begun in clearing out the brush and sprout growth in the infested region, creosoting the egg clusters, and preparing for effective summer treatment. Five new towns were found infested with the gipsy moth as a result of scouting work during the winter of 1907–8, namely, Berwick, North Berwick, Sanford, Lebanon, and Acton.

FIG. 16.—Pile of 120,000 webs of the brown-tail moth gathered and destroyed at York, Me. (From Hitchings.)

The following summer the infested areas were burlapped and given careful attention, especially the one at Togus, where an attempt was made by the Maine department of agriculture to secure the extermination of the insect. The work at this point was especially difficult, owing to the large number of people who visited the home during the spring and summer, and because it was not possible to remove some of the board walks, which furnished excellent places for the moths to deposit egg clusters. The trees surrounding the one infested were burlapped and tended during the summer, and in the fall the grounds were thoroughly scouted for egg clusters. In addition to the caterpillars, pupæ, and moths found when the burlap bands were turned, 40 egg clusters were found and treated.

As a result of the thorough work done only a few caterpillars and no egg clusters were found in the summer of 1908, and although the same methods have been employed as in previous years none of the insects was found in 1909. The last specimen taken was a caterpillar, July 11, 1908. It is probable that this colony has been completely exterminated, although the location and character of the place render it peculiarly liable to future infestation. Since the year 1907 the gipsy moth state work has been under the general oversight of Capt. E. E. Philbrook, and the state force has worked in close cooperation with the government office. The work has been especially difficult, owing to the necessity for training new men, and also because the country along the Maine coast, which is infested, is rough and broken and furnishes opportunity for egg clusters to be hidden in situations where it is almost impossible to find and destroy them. During the winter of 1908–9 scouting work was continued, and small infestations were found in Newfield, Waterboro, Biddeford, Saco, and Scarboro. All the known colonies in Maine have been given most thorough attention, and their condition has improved each year. An important feature of the work has consisted in sending out scouting parties to examine the roadways, orchards, and places likely to be infested outside of the known infested area. This has been done in a limited way, but more work of this character must be taken up in order to determine positively the extent of the infestation. During the fall of 1909 the scouting work was pushed vigorously, not only along the roadways and in the orchards, but crews of trained men were sent into the woodland area to make thorough inspections. Three towns, namely Shapleigh, Gorham, and Dayton, have been found slightly infested, and during the progress of the work a large woodland colony was found in the Agamenticus district in the town of York. The location of this colony is in a region seldom frequented and practically inaccessible to travel. Scouting is being continued for the purpose of discovering any similar colonies that have not yet been found.

The work in Maine has been carefully and thoroughly prosecuted, and the state officials have shown much interest and enthusiasm in meeting this difficult problem. A force of men has been organized and trained to a high degree of efficiency. During the time the work has been in progress it has met with the hearty approval and cooperation of citizens in the infested district. As an example of the esteem in which the work is held it may be stated that during the past year the summer residents and public-spirited citizens of York contributed $1,000 and purchased a power spraying machine, which was turned over to the Maine department of agriculture for treating infested areas.

The amount appropriated by the State from 1905 to January 1, 1910, has been $95,000, and $50,000 additional has been used by the Bureau of Entomology in the moth work in Maine.

WORK IN THE STATE OF NEW HAMPSHIRE.

The first infestation of the gipsy moth in New Hampshire was discovered in 1905 by inspectors from the Massachusetts state office, loaned by agreement between Mr. Kirkland and the New Hampshire experiment station. Three experienced men were detailed and the experiment station sent Mr. W. P. Flint, an assistant in the entomological department, to make an examination of the trees along the roads in the coast towns from Seabrook to Portsmouth. Egg clusters were found in these towns and also in Hampton Falls, Hampton, North Hampton, Rye, and Greenland. Additional scouting was done in Exeter and Nashua, but no evidence of the moth found.

The brown-tail moth had already thoroughly established itself in southern New Hampshire and was causing great injury to orchard, shade, and forest trees.

No state funds were available for moth work. In 1906 a request was made for assistance from this office, soon after the first appropriation was available, but it was too late to do any effective work against the caterpillars, and as no serious outbreak of the pest was evident, scouting was deferred until winter, when an examination showed that the gipsy moth was present in 36 municipalities in the southeastern part of the State.

At the 1907 session of the legislature a law embodying some of the principal features of the Massachusetts law was enacted, and $12,500 appropriated for each of the years 1907 and 1908. The enforcement of the law was placed in the hands of the governor and council with authority to appoint a state agent, if it was deemed necessary. During the first year the burlap work was let out by contract, and Mr. G. E. Merrill, of Hampton Falls, N. H., was employed to inspect the work of the contractors.

All trees within about 100 feet of infested trees in the towns east of Pelham along the Massachusetts border, and the coast towns to Portsmouth, were burlapped and tended, and although some benefit resulted, the amount of money available was entirely inadequate to accomplish satisfactory results. At the close of the year Col. Thomas H. Dearborn, of Dover, was appointed state agent, and has since that time had charge of the moth work.

The appropriations made by the State have not been increased, although the scouting operations of the Bureau of Entomology have resulted in the discovery of the gipsy moth in more than 100 cities and towns. All of Rockingham, Strafford, and Belknap, most of Hillsboro and Merrimack counties, and a few towns in Carroll County are infested—an area of about 3,000 square miles. All the roadsides and orchards in this entire territory have been examined, and similar work has been done in a tier of towns surrounding the infested region,

in an attempt to determine the extent of the infestation and to prevent the spread of the pests from colonies along the highways. For three years the greater part of this territory has been inspected in a similar manner.

During the summer thousands of people from all sections of the country visit the State, which is noted for its summer resorts and mountain scenery, and this has been a potent factor in dispersing this insect. Many automobile parties tour the State, and not infrequently trips are made from Boston and vicinity to the White Mountains and lake resorts. During the time the gipsy moth was allowed to develop without interference in Massachusetts, excellent facilities were offered for its dispersion throughout New Hampshire. Travel is unusually heavy at the opening of the vacation season, which is the time when the larvæ are small and most easily carried.

The scouting operations have resulted in locating many colonies in and around summer camps and country houses frequented by vacationists who come from badly infested districts in Massachusetts.

The most serious feature of the problem in New Hampshire is the undoubted infestation of a large part of the thickly wooded area in the southern part of the State. Remedial measures are entirely impracticable, as it is impossible to apply them to such large areas of low-priced forests, owing to the great expense involved.

The greater part of the area is not yet badly infested, but unless the people of the State become aroused and exert themselves to check the gipsy moth serious injury will be caused to the trees and enormous loss is bound to result.

In the residential sections the people will, when the moth increases to an extent to cause serious injury, undoubtedly awake to the situation, and exert themselves to preserve their trees.

The brown-tail moth has been found in an area covering over one-half of the State, and in the entire section east of the Connecticut River watershed and south of Lake Winnepesaukee it is most abundant and is causing great damage. Its presence has caused much complaint from residents and summer visitors, and this has led to effective work being done along the roadways and in some of the towns. Colonel Dearborn has succeeded in awakening considerable interest in this work in certain sections of the State, and some relief from this troublesome pest has been secured where it has been possible to sufficiently arouse public sentiment.

The State has spent $37,500 and the Bureau of Entomology about $90,000 in the work in New Hampshire.

WORK IN THE STATE OF RHODE ISLAND.

The presence of the gipsy moth in Providence was discovered in 1901, and some effort was made by the city and property owners to

destroy the insect during the following two years. In 1906, the year after the state work was begun in Massachusetts, a law was enacted in Rhode Island providing for control measures against the gipsy moth. An appropriation of $5,100 was made. This was inadequate for the work, but by means of a cooperative arrangement between the state superintendent, Prof. A. E. Stene, and the Bureau of Entomology it was possible to carry on a vigorous campaign. The original infestation was confined almost entirely to residential property, and at the present time very little woodland in the State of Rhode Island is known to be infested.

Infestations have been found in 11 towns in the northeastern part of the State, extending from the Massachusetts line and including one tier of towns west of the city of Providence. The work which has been done has resulted in the extermination of a large number of small colonies, and those localities in which the moth is now present are of limited extent and are being given careful attention. In many cases the caterpillars or egg clusters were found in brush and undergrowth growing on dumps or unimproved building lots and much work has been required to clean up infestations of this character.

Since the work began practically all of the State has been scouted except the towns north of Westerly along the Connecticut line.

In 1907, $10,000, in 1908, $10,000, and in 1909, $8,000, was appropriated for moth work, and with the help which has been furnished by the Bureau of Entomology great progress has been made. Each year all the trees in the infested area have been carefully examined and fences, buildings, and shrubbery thoroughly inspected for egg clusters. In order to check up the work two experts have gone over the territory after the regular workmen in order to ascertain if any egg clusters had been missed.

During the summer of 1909 about 150,000 trees were burlapped in Providence and surrounding towns. These were visited twice a week during the caterpillar season, and all the insects found were crushed by the workmen. The cavities in a large number of trees in the infested section have been filled with cement or covered with zinc so that work can be more thoroughly done. In order to show the progress which has been made in Rhode Island, it should be stated that during the winter of 1906–7 nearly 80,000 egg clusters were found and destroyed. During the following winter, 1907–8, only 7,500 egg clusters could be found, and in the winter 1908–9 but 1,700 were discovered and treated. It is believed that the moth has been exterminated in 4 of the 11 towns which were infested. The entire territory in this State is in excellent condition, and very little injury now results to the trees, as the insect is present only in small numbers. With persistent work for a number of years it should be possible

totally to exterminate the insect in this State, but this can not be accomplished and the region kept free from infestation unless the vigorous work which is now being carried on in the other New England States is maintained. Throughout the period that the work has been in progress in Rhode Island most cordial relations have existed between the state superintendent and this office, and this is one of the factors which has made the work so successful.

The amount appropriated by the State during the four years the work has been in progress is $33,100. In addition to this the National Government has expended about $28,000.

WORK IN THE STATE OF CONNECTICUT.

Adult specimens of the gipsy moth were found by Mr. Ernest Frensch, a local collector of insects, at Stonington, Conn., near the Rhode Island state line during the summer of 1905. He reported the matter early in the year 1906 to Dr. W. E. Britton, state entomologist of Connecticut, who at once made an investigation and found that the report was correct. An emergency fund was available in that State, and was placed at the disposal of the state entomologist for the purpose of stamping out the pest.

The work has been managed in a very efficient manner, and each year such assistance as was desired has been furnished by the Bureau of Entomology. The original infestation covered practically 1 square mile, this having been determined by very careful scouting operations. This colony has been very difficult to treat successfully owing to the broken and rocky character of the ground and to a large number of pastures and brush-covered areas which furnished excellent places in which the eggs of the moth could be deposited. In the autumn of 1906 a determined effort was made by the state entomologist to exterminate the moth in this town, and all brush was cut in the woodland and pastures throughout the infested area. The following summer the trees were burlapped after having been previously pruned and all cavities sealed with cement or patched with zinc. Many stone walls were burned out with a cyclone burner, some spraying was done during the caterpillar season, and a number of trees were banded with tanglefoot. Working on the theory that colonies originated from the introduction of caterpillars by some peddler or milkman or other person making frequent visits over quite a large area, several of the adjoining towns were scouted to determine if other colonies existed from which these caterpillars might have been distributed. No evidence was found, however, of outside colonies. During the summer of 1906 approximately 10,000 caterpillars were destroyed, and during the winter of 1906–7, 118 egg clusters were treated with creosote. By following up the methods already outlined the infestation has decreased each year, and during

the summer of 1909 less than 100 caterpillars were killed. The final inspection recently completed revealed the presence of only 1 egg cluster. The condition of this colony in Connecticut is very satisfactory and much credit is due the state entomologist and his assistants for the efficient work which has been done. A small amount of help has been furnished by the Bureau of Entomology when it was desired, and it is evident that extermination can be accomplished by following up the work in a thorough manner, although the territory is a most difficult one to treat.

On December 14, 1909, a letter was received from Dr. W. E. Britton stating that a colony of the gipsy moth had been found in the town of Wallingford, about 12 miles north of New Haven. Several men were immediately sent by him to investigate the matter thoroughly, to determine the amount of territory infested, and to treat egg clusters. On December 20, Mr. Rogers and Doctor Britton visited Wallingford and saw many badly infested trees near the center of the town. The examination which had been carried on previous to that time showed that the moth had spread over approximately one-half of the borough. The principal infestation was located in the rear of a grocery store, and during the caterpillar season delivery wagons and other vehicles must have furnished excellent opportunity for the spread of the insects. Undoubtedly, a considerable area will be found infested after a thorough examination has been made. It is probable that this colony has existed for at least three years, and possibly for a longer time. The total number of egg clusters treated up to January 1, 1910, aggregated over 5,000.

The presence of this bad colony, which is at least 100 miles from the badly infested area in Massachusetts, indicates the probability that other colonies may exist at equally distant points. From the fact that the center of the infestation appears to be near the provision store mentioned, and also because lettuce, cucumbers, and other garden crops were undoubtedly shipped to this point from market gardens near Boston, it is possible that the infestation may have been caused by egg clusters brought in boxes used for transporting these products. If this supposition is correct, it is probable that many points outside the infested district in Massachusetts became infested in this way during the years when no work was done in that State. Every effort will be made to stamp out the pest in Wallingford, and arrangements are on foot to place a sufficient number of men in the town to thoroughly inspect and treat the infested area, and to examine carefully the surrounding territory.

INSPECTION OF LUMBER AND FOREST PRODUCTS.

On March 27, 1909, a letter was received from Mr. A. M. G. Soule, one of the foremen in charge of the scouting work in Maine, which

stated that while examining woodland along the railroad near Scarboro Beach, Me., he found a quantity of oak shim wood, which was being used by the section men in repairing the track, badly infested with gipsy moth egg clusters.

An investigation showed that the wood was originally shipped from a badly infested district near Bedford, Mass., and that it had been delivered at various section houses along the railroad between South Lawrence, Mass., and Portland, Me. By following up the deliveries, infested wood from this shipment was found at Kennebunk, Biddeford, Pine Point, and Scarboro Beach, Me. The entire shipment, so far as could be determined, was traced and the egg clusters treated wherever they were found. This discovery emphasized the danger of shipping forest products of all kinds by rail after the egg clusters of the gipsy moth had been laid, and arrangements were at once made to inaugurate a system of inspection by means of which distribution of egg clusters from the infested area to distant points could be prevented. The matter was presented to the Chief of the Bureau of Entomology, and later a letter was sent by the Secretary of Agriculture to the different railroad companies operating in the infested district, requesting their cooperation with the Bureau of Entomology in preventing further spread of this insect. The officials of the several railroads operating within the infested district gave assurance of their interest in the matter, and promised all possible assistance in confining the pest to the present territory. Orders were issued by the railroads to all station agents within this area that after July 1, 1909, forest products would be accepted for shipment only when accompanied by permits or certificates of inspection from this office. As soon as shippers became acquainted with the requirements little delay was experienced, and the order has met with hearty approval and a generous spirit of cooperation. When such material is being forwarded from one town in the infested district to another known infested point, a permit to ship is granted after proper application has been made. The inspection of such shipments is not attempted unless there is special danger of transmitting infested material. On shipments, however, that are destined to points outside the infested territory, inspection is made by employees of this office before a certificate is granted allowing shipments to move. As a result of this work, inspections have been made of 490 shipments, many of which were badly infested. The following table gives the geographical range of the shipments sent out from infested territory from July 1, 1909, to January 1, 1910. Each shipment averaged about a carload lot, although in some cases as high as 10 carloads were examined for a single shipment. Over 1,000 cars of forest products have been shipped from the infested

district in Maine during this period. Practically all the lumber region in this State is outside the infested area.

This material consisted chiefly of railroad ties, posts, poles, cord wood, bark, staves, rough lumber, and, in the last few weeks of 1909, small evergreen trees for the Christmas trade. The enforcement of the inspection requirements has resulted in a large amount of additional work for this office, but as several badly infested shipments have been prevented, the expense of the work has been amply justified. A large shipment of lumber consigned to Holyoke, Mass., was found badly infested, and held until it could be thoroughly inspected and treated before it was allowed on the cars. Lumber which was destined to Philadelphia, Pa., and other points as far removed from the infested region was also held up for thorough inspection and certification. This has been the means of preventing a number of colonies from gaining a foothold in States outside of New England.

Number and geographical distribution of lumber shipments forwarded to uninfested points.

CONNECTICUT.

Ansonia, 4.
Bridgeport, 11.
Danbury, 2.
Derby, 2.
Greenwich, 1.
Hartford, 7.
Litchfield, 1.
Lyme, 1.
Meriden, 3.
New Haven, 13.
New London, 2.
Norwich, 2.
Seymour, 6.
Torrington, 2.
Waterbury, 5.

ILLINOIS.

Chicago, 1.

MAINE.

Auburn, 1.
Buxton, 2.
Freyeburg, 2.
Millinocket, 2.
Portland, 35.
Westbrook, 4.

MASSACHUSETTS.

Acushnet, 1.
Amherst, 1.
Athol, 3.
Barre, 2.
Fair Haven, 1.
Fall River, 7.
Holyoke, 25.
New Bedford, 4.
Northampton, 1.
Royalston, 1.
Shelburne, 1.
Southbridge, 2.
Springfield, 2.
Ware, 2.
Winchendon, 2.

NEW HAMPSHIRE.

Berlin, 1.
Campton, 1.
Canaan, 2.
Claremont, 1.
Conway, 1.
Gorham, 1.
Greenfield, 4.
Hancock, 2.
Harrisville, 6.
Haverhill, 4.
Keene, 10.
Lisbon, 1.
Madison, 2.
Marlboro, 3.
Newport, 2.
Peterboro, 9.
Plymouth, 1.
Rumney, 1.
Swanzey, 1.
Winchester, 1.

NEW JERSEY.

Camden, 2.
Edgewater, 1.
Edgeworth, 1.
Helmetta, 1.
Hoboken, 1.
Irvington, 1.
Jersey City, 2.
Keyport, 1.
Newark, 3.
New Brunswick, 2.
Passaic, 3.
Paterson, 1.

NEW YORK.

Albany, 1.
Arden, 1.
Brooklyn, 1.
Claremont Park, 1.
Cornwall, 2.
Dunkirk, 2.
Hornell, 1.
Ilion, 1.
Kingston, 1.

NEW YORK—continued.

Long Island City, 2.
Morris Heights, 1.
Mount Kisco, 1.
New Hartford, 2.
New Rochelle, 1.
New York City, 7.
Oneida, 1.
Peekskill, 1.
Port Chester, 1.
St. Johnsville, 1.
Seacliff, 1.
White Plains, 2.

OHIO.

Sandusky, 5.

PENNSYLVANIA.

Allentown, 1.
Pen Argyl, 1.
Philadelphia, 18.

RHODE ISLAND.

Bristol, 2.
Coventry, 2.
Newport, 2.
Woonsocket, 2.

VERMONT.

Barton, 4.
Bellows Falls, 1.
Brattleboro, 1.
Lyndon, 1.
St. Johnsbury, 1.

DISTRICT OF COLUMBIA.

Washington, 2.

Aside from the certificates required for shipping forest products outside the infested territory, a large number of permits, aggregating 2,624 to January 1, 1910, have been issued allowing the transportation of these products inside the infested district.[a]

This inspection feature of the work is of great importance and must be well organized and thoroughly enforced if the gipsy moth is to be prevented from becoming established at distant points. This is especially true, since at the present time large forest areas are heavily infested, and in order to harvest the marketable lumber many owners are cutting and shipping. Where large cutting operations are carried on it is customary to use portable sawmills, and the rough lumber is often piled in the woodland where it may remain one or two seasons. This may result in the lumber becoming badly infested with egg clusters. (See Pl. VIII.) A number of cases have been found which indicate that the moth has been spread by the removal of these portable sawmills from one infested area to another where no infestation existed.

The report has recently been received that gipsy moth egg clusters were found in Providence, R. I., on boxes which had been used by market gardeners in shipping their produce. This feature concerning the spread of the moth is very difficult to regulate, and about the only measure seems to be the requiring of shippers of such produce to keep their grounds and premises free from the pest. The thorough inspection and cleaning up of such premises will undoubtedly result in checking the spread of the insect in this way.

DANGER OF INTRODUCING THE GIPSY MOTH AND BROWN-TAIL MOTH FROM FOREIGN COUNTRIES.

The suppression and inspection work which is being carried on in New England of course can not prevent the introduction of these

[a] From January 1, 1910, to May 25, 1910, 227 certificates and 102 permits were issued. Several infested shipments were found, which were carefully treated before being released. In addition to the New England States these shipments were sent to New York, Pennsylvania, Delaware, Virginia, and Ohio.

LUMBER PILES AT YORK, ME., INFESTED WITH EGG CLUSTERS OF THE GIPSY MOTH.

pests from foreign countries, and unfortunately at the present time there is no effective general law which provides for the inspection of nursery stock or other products, coming into the country, on which these insects are likely to be transported. Most of the States have nursery inspection laws which are enforced with special reference to preventing the introduction and spread within the State of the San Jose scale and other dangerously injurious insect pests. Most of these laws are well enforced, and the officials in charge have been provided with sufficient funds to carry on the work. The ports of entry, which are controlled by the United States Government, have not come under the jurisdiction of the State officials, and when inspections were made of stock coming to the United States from foreign countries, they have been carried on at the point of destination. Little attention was given to this feature of nursery inspection work until during the winter of 1909 discovery was made by the inspectors working under the direction of the commissioner of agriculture of New York that seedling nursery stock imported from France was being received at various nurseries in the State, which in many cases bore webs containing hibernating caterpillars of the brown-tail moth. This matter was given immediate attention, and the inspectors in the different States were cautioned, both by the commissioner of agriculture of New York and the Chief of the Bureau of Entomology at Washington, to be on the lookout for such stock. As a result of this warning and of the arrangements made by the Bureau of Entomology with the custom-house officials, notice was sent to inspectors in all of the States of the arrival of any nursery stock shipments in this country, so that an inspection could be made as soon as the stock reached its destination. Most of the States followed up the shipments energetically, and carefully inspected them, but in a few where no funds were available for doing the work the local inspector was deputized by the Bureau of Entomology to examine the importations and the work was paid for out of the appropriation for preventing the spread of moths which had been made for carrying out the campaign in New England.

At the close of the season it was found that brown-tail moths had been found in shipments of stock that had been received in 15 different States, viz, Alabama, Georgia, Illinois, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Missouri, Nebraska, New Jersey, New York, North Carolina, Ohio, and Pennsylvania. In New York State alone over 7,000 webs were found and destroyed. A single egg cluster of the gipsy moth was found in a shipment received in Ohio.

A bill (H. R. 23252, 61st Congress, 2d Session) "To provide for the introduction of foreign nursery stock by permit only, and to authorize the Secretary of Agriculture to establish a quarantine against the

importation and against the transportation in interstate commerce of diseased nursery stock or nursery stock infested with injurious insects, and making an appropriation to carry the same into effect" is now under consideration by the Committee on Agriculture of the House of Representatives and it is earnestly hoped that it may receive favorable action. The urgent need of some legislation of this character should be apparent to any person who has given the matter serious thought. From a financial point of view it is much easier and cheaper to stamp out a few insects before they have had an opportunity to gain a foothold in this country than to attempt to exterminate or suppress them after they have had a chance to multiply and become acclimated.

EXPERIMENTAL WORK IN THE CONTROL OF THE GIPSY AND BROWN-TAIL MOTHS.

During the progress of the field work on the gipsy and brown-tail moths it has been necessary to carry on a limited number of experiments and to make investigations so that more economical methods could be used in destroying these insects. It has been known for years that a single defoliation will cause the death of pine or other coniferous trees and some of the men engaged in the field work reported that small caterpillars of the gipsy moth did not appear to feed on the foliage of these trees. In 1907 Mr. F. H. Mosher, one of the entomologists connected with the Massachusetts work, carried on an extensive series of experiments in feeding newly hatched gipsy-moth caterpillars on pine foliage. The results secured showed that the caterpillars would starve rather than eat the food offered, and as a result of this test it became evident that it was necessary for the small caterpillars to have a considerable amount of deciduous food before they were able to attack pine. Using these experiments as a basis, an extensive field test was made in the spring of 1908 by the Bureau of Entomology in cooperation with the Massachusetts state office.

An area of about 5 acres of pine woodland located in Arlington, Mass., was selected for the test. The woodland was surrounded by farm land upon which were growing many fruit and shade trees, as well as a considerable amount of brush and undergrowth, all of which was very badly infested with the gipsy moth. The pine trees were banded with tanglefoot early in the spring and no other treatment was applied except combing the bands. These trees, as well as the deciduous trees on the surrounding ground, were badly infested with egg clusters of the gipsy moth. After the caterpillars hatched, the deciduous trees were badly defoliated, but no injury resulted to the pines. The small caterpillars in the pine trees, being unable to secure

FIG. 1.—PINE GROVE KILLED BY THE GIPSY MOTH. (ORIGINAL.)

FIG. 2.—PINE TREES THAT HAVE BEEN PROTECTED FROM THE ATTACKS OF THE GIPSY MOTH. (ORIGINAL.)

proper food for their development, either died or spun down to the ground and migrated to the deciduous growth. Owing to the sticky bands on the trunks of the trees it was impossible for the caterpillars to again ascend to the foliage. This experiment was checked up by several other tests made by the state office, all of which showed the same results. (See Pl. IX, figs. 1, 2.)

The practice at present in handling coniferous woodland is to cut out all the deciduous growth which will furnish food for the young caterpillars, and if the pines are well banded with tanglefoot early in the summer, and these bands kept viscid during the caterpillar season, no further treatment is necessary. These experiments have resulted in the adoption of a simple and comparatively cheap method of preventing the destruction of valuable coniferous woodland, and as trees of this character grow satisfactorily in most sections of the infested district it is possible to preserve and develop pine forests at a moderate expense, regardless of the presence of the gipsy moth in surrounding territory.

The greater part of the experimental work has been along the line of developing more efficient spraying methods. The use of the tower on power sprayers, which will be more fully explained later in this report, has resulted in a great saving in cost of treatment. In the summer of 1909 several tests were made with large spraying machines to determine the most effective pressures and the best size of nozzle outlets. The results indicate that on the average a $\frac{1}{4}$-inch nozzle of the type described later in this report will carry the spray 20 feet farther than a $\frac{3}{16}$-inch nozzle, and that it is necessary to maintain a pressure of over 200 pounds in order to secure satisfactory results. There are many opportunities for perfecting the present spraying outfit, and much thought is being given this matter both by the Bureau and state officials as well as by manufacturers who at the present time are selling many spraying machines in the infested region. The activity in perfecting devices will undoubtedly result in better and more economical methods in the future.

METHODS NOW USED IN FIGHTING THE GIPSY MOTH.

Most of the methods used for destroying the gipsy moth have already been mentioned, and a large number of them were in successful use at the time the work was being carried on by the State of Massachusetts during the nineties. Such methods as treating egg clusters, cleaning up brush, thinning infested woodlands, and general clearing-up measures have not been improved to a great extent. The use of burlap has been continued from year to year, but owing to the expense involved in applying and tending it throughout the season it is not now considered as satisfactory a method as the more recent

system of banding the trees with tanglefoot. This is especially true since the brown-tail moth became abundant in the orchards and woodlands. Many of the caterpillars of this insect seek the burlaps when they are about to spin their cocoons for the purpose of pupation, and the serious poisoning which results to the men employed when turning such burlaps makes thorough work well-nigh impossible. Every season hundreds of men suffer extremely from this trouble, and in many cases efficient and well-trained workers are obliged to resign rather than attempt to continue on the work. This is leading to a general discontinuance of the burlap method of treating the gipsy moth. The tanglefoot bands are very satisfactory and the men are enabled to work with less discomfort. The methods used in cutting out zones along infested roadways has been in strict accordance with the latest ideas of modern forestry.

FIG. 17.—Roadside area, showing how the grass has been induced to grow by thinning out the trees and clearing away the underbrush in gipsy-moth control work. (Original.)

By adopting the best known methods in thinning and pruning, the trees which remain are in sound condition, and with the care which is given from year to year after the roadways have once been thinned they have a favorable opportunity to make a satisfactory growth. In many of these cleaned areas, which are kept free from undergrowth by mowing them in August, it has been possible to induce a stand of grass which greatly improves the entire appearance and condition of the roadside. (See fig. 17.)

Perhaps the greatest advancement has been made in spraying with arsenicals. Since the discovery of arsenate of lead this substance has practically superseded all other poisons for use against leaf-eating insects of all kinds. During the season of 1909 nearly

500 tons of this poison were used in New England for spraying the trees. Considerable spraying was done to destroy the elm leaf-beetle (*Galerucella luteola* Müll.), and this poison was used exclusively in the work. The best results are secured in spraying for the gipsy moth when the caterpillars are very small, but in covering so large an area it is impossible to provide machines enough to do all the work early in the season. Ten pounds of arsenate of lead to 100 gallons of water is a satisfactory strength to use, but after the caterpillars are half grown it is often desirable to increase this amount to 12 or 15 pounds to the same amount of water. Spraying late in the season after the larvæ are nearly fullgrown is of doubtful advantage, as the caterpillars are very resistant to poison, and as a rule will pupate and transform to moths.

The power spraying machines used in 1909 were superior in every way to any that had been designed previously, and plans for improvements on these machines have been considered for the work next season. Barrel sprayers fitted with hand pumps are used to some extent for treating shrubbery and orchards, and in some cases high trees are treated by using these outfits, especially when it is necessary to prevent buildings from becoming discolored by the poison. The use of these small outfits is impracticable when it is necessary to cover in a period of six weeks the large areas which must be sprayed, and as a result of varied tests of power outfits a system has been devised for using what is known as "solid-stream spray."

About 1895 Mr. J. A. Pettegrew, who was then superintendent of Prospect Park, Brooklyn, N. Y., constructed a steam spraying outfit for use in treating the trees which were being severely injured by the elm leaf-beetle. Sufficient pressure was developed to spray high trees from the ground, the shape of the nozzle being such that a solid stream was carried high in the air, where it was broken into a mist. This sprayer was described and illustrated by Dr. L. O. Howard in an article on spraying.[a] Soon after Mr. Pettegrew became superintendent of the Boston city parks he used a similar outfit for spraying.

In 1905, this method of treatment was tested by Gen. S. C. Lawrence, of Medford, Mass., who was carrying on extensive spraying operations to protect the trees from the gipsy moth. This outfit was built by a Boston firm, and was equipped with a high-power gasoline engine instead of with steam to generate power. The experiment was successful and since that time the use of outfits built on the same general lines has been gradually increasing. Mr. George H. Kermeen, one of the representatives of the firm alluded to, was an early advocate of this system of spraying, and in addition to

[a] "The use of steam apparatus for spraying," Yearbook, U. S. Department of Agriculture, 1896.

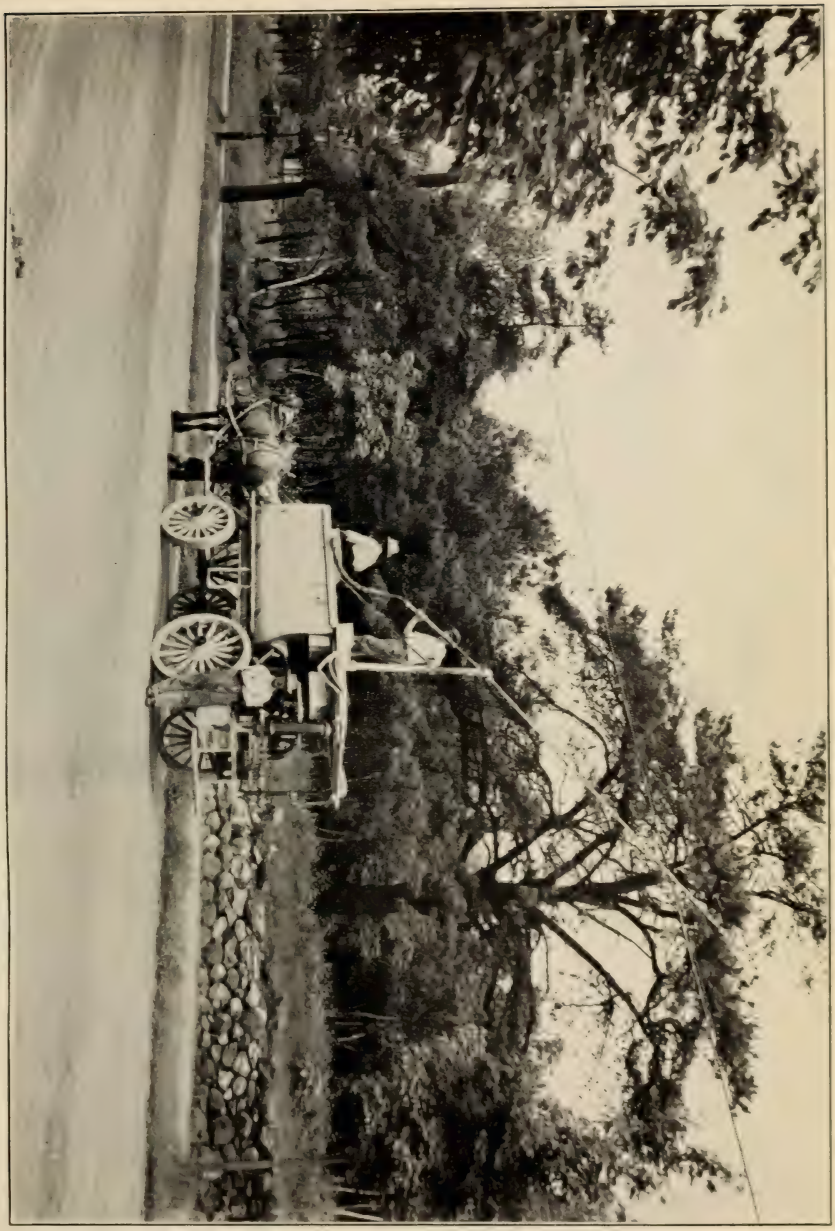
making improvements in the outfits succeeded in interesting many people in their use.

Experiments were carried on under the direction of Mr. A. H. Kirkland and Mr. L. H. Worthley, and others connected with the state office in Massachusetts, and considerable work along this line has been attempted by Mr. Rogers and others connected with this office, and the results have been of benefit to all workers against the moths. The most successful machine thus far designed is provided with a multiple-cylinder (usually triplex) pump which is connected by a clutch to a gasoline engine of the marine or auto type. The engine is provided with two or more cylinders. The four-cycle type of engine has given the most successful results. A bronze pump is used, as this metal accommodates itself to sudden fluctuations in pressure and is not affected as readily with arsenate of lead as those made of cast iron.

The pump must be capable of delivering 35 gallons per minute and maintain a pump pressure of at least 200 pounds. This requires a 10-horsepower engine. Piping is arranged so that water may be pumped into the tank from accessible wells, ponds, or streams, and solution pumped from the tank and not discharged by the nozzle returns either to the tank or into the pump suction. A large, strong air-chamber is necessary in order to avoid sharp shocks to the pump and also to equalize the pressure. Batteries should be placed where there is as little jarring as possible, away from the heat of the engine, and where water will not reach them. One of our machines has been fitted with a magneto with excellent results. Engines and motors of the two and four cycle types have been used and both water and air cooled engines have been tested. Until recently only gas engines of the stationary type were used, but last summer the two-cylinder marine motor, water cooled, gave excellent results, and a four-cylinder engine of this class will perhaps be still more satisfactory.

The agitation of the solution is accomplished by a shaft fitted with 2 or 3 two-bladed propellers, which passes through the lower part of the tank. It is operated by the engine so that the poison is thoroughly mixed. One-and-one-fourth-inch hose has been used for spraying with these machines, but at the present time 1-inch hose is coming into favor. The nozzle is of much the same type as that used on fire hose, being fitted for interchangeable tips, varying from $\frac{1}{8}$-inch to $\frac{1}{4}$-inch aperture.

The machinery is mounted on the back part of a wagon truck, the front part being occupied by a 400-gallon to 500-gallon U-shaped tank. The trucks are as short as possible to accommodate the tank and necessary machinery and are provided with stout springs and brake. They are also built so that the front wheels will cut under the tank, as this is of advantage in turning around in narrow streets.



ONE OF THE TEN HIGH-POWER SPRAYING OUTFITS USED IN THE GIPSY MOTH WORK OF THE BUREAU OF ENTOMOLOGY. (ORIGINAL.)

HIGH-POWER SPRAYING OUTFIT IN USE IN TREATING ROADSIDE TREES. (ORIGINAL.)

When a machine of this type (Pl. X) is used and a pressure held at from 200 to 250 pounds, trees from 60 to 75 feet high can be thoroughly sprayed from the ground. It is necessary in spraying the woodland areas to use long lines of hose, and this requires the use of a considerable number of men to move the hose about rapidly, so that the spray material can be well distributed by the man holding the nozzle. In the work along roadsides this system was used in 1907 with satisfactory results, but the time required for moving the hose greatly increased the cost of treatment. In order to diminish the cost of applying poison to the roadside areas, and also to enable the workmen to treat a greater mileage in a given length of time, a special arrangement was devised by Mr. Rogers which is known as a "water tower." This is set up on top of the tank and is mounted on a mast 6½ feet high made of 2½-inch piping which is provided with braces to hold it in perpendicular position. It is attached to the top of the tank with bolts so that it can be laid down when not in use. At the top of the mast is a threaded street L made on free to the mast and a T is made onto the L in such a manner as to provide what is practically a universal joint. Through the T a length of 1¼-inch, 16-gauge steel tubing is placed, which is fitted with collars to hold it firmly in position. The tube is about 20 feet long; at the outer end the nozzle is attached, while to the other, which extends only about 4 feet from the point of attachment to the mast, is coupled the hose carrying the solution.

The tube near the end where the hose enters is reenforced by a quantity of lead which makes it nearly balanced on the mast. The nozzle is raised by lowering the reenforced end of the tube, and when the sprayer is in operation the nozzle is about 25 feet from the ground. With this arrangement, if the pressure is maintained at 200 pounds and a ¼-inch nozzle used, trees 80 to 90 feet in height can be readily sprayed. If the wind is light or favorable, a strip along one side of the road 100 feet deep, or more, can be treated. It is impossible to use this arrangement with satisfactory results if the wind is blowing from the strip, but under favorable conditions good work can be done if the sprayer moves along the road while the machine is in operation. (See Pl. XI.) It is more effective to spray these strips twice, as this assures better distribution of the poison. A modification of this system was tried during the past summer and consisted simply of using the tower for elevating the spray and treating the high trees and growth as far back as possible from the roadway, while at the same time another hand nozzle, with smaller tip of the same type as the one on the tower, was operated by a man standing on the top of the tank. The latter nozzle was used for treating the trees close to the road, and by this modification more thorough work was done. (See fig. 18.)

It is obvious that the tower can not be used except for treatment of roadsides, and where woodland areas are to be sprayed it is often necessary to lay long lines of hose from the sprayer, which should be located as near as possible to a supply of water. The State of Massachusetts has conducted large spraying operations over thousands of acres of forests of this character in the North Shore district with excellent results. In some cases a line of hose more than one-fourth of a mile long has been used, and it was possible to maintain sufficient pressure at the nozzle to do satisfactory work. Woodland work of this character is very expensive, owing especially to the amount of labor required to carry the hose. A machine and crew of men can usually cover about 12 acres of woodland per day, the entire cost of treatment averaging about $10 per acre. Roadsides can be

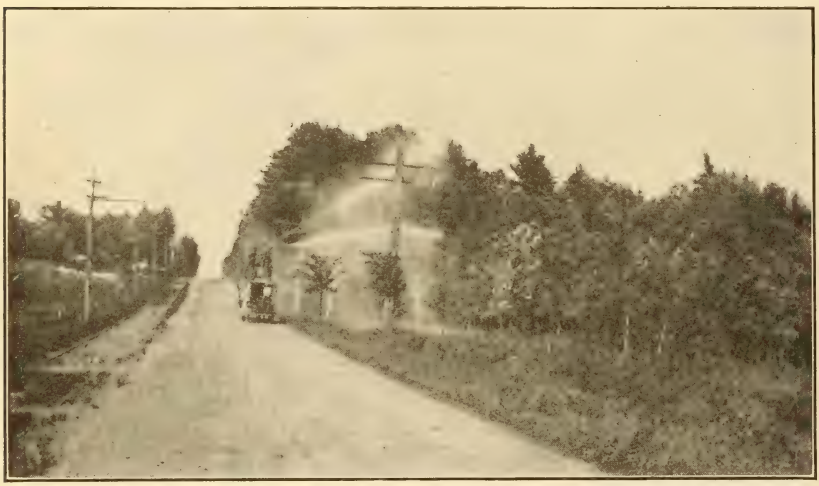


FIG. 18.—Spraying a roadside, using a combination tower and hand nozzle, so as to throw two streams. (Original.)

treated, where the tower is used, for about $2 per acre, and it is possible under favorable conditions to spray 2 miles in a single day.

With the last mentioned outfit it is necessary to employ two men to operate the nozzles, an engineer to look after the machine, and a team and driver. A driver with a horse and wagon accompanies each sprayer with a supply of poison, gasoline, extra hose, etc. The driver of the supply wagon is required to post warning notices in the treated strips, which indicate that spraying has been done, so that owners of cows and other animals will not permit them to feed on the sprayed foliage or grass.

Under favorable circumstances from 4,000 to 5,000 gallons is sprayed out in 8 hours, but this amount is sometimes reduced by each machine, owing to pump or engine troubles.

COST OF METHODS EMPLOYED.

In the gipsy moth work it is very necessary to know the approximate cost of cleaning up or caring for any given infested area. The treatment work attempted by the Bureau has been principally along the line of caring for trees growing near wooded roadsides, while that of the States has covered infested areas of all kinds. In the latter work, especially in woodland areas, much money has been expended in thinning out the trees and putting the forests in the best possible condition, so that the moth can be successfully treated. Special attention has been paid to leaving trees which would be the most profitable, and also those which are to some extent immune from the feeding of the insect.

Mr. L. H. Worthley, assistant forester in charge of moth work for the State of Massachusetts, who has had wide experience in cutting-out operations, states that woodland can be properly thinned (not pruned) and put in condition for treatment measures against the gipsy moth at a cost ranging from $15 to $35 an acre. This variation depends on the character and size of the trees to be cut. The first roadside work done by this office where considerable heavy timber was cut cost about $40 an acre for thinning, burning, pruning, and creosoting egg clusters. As the force of men became more experienced in the work it has been possible to reduce the expense of cutting out these roadside strips. The average cost of work on over 30 miles of strips last fall amounted to $27.50 an acre. It may seem at first glance as though this method required an excessive expenditure of money; nevertheless it should be stated that the gipsy moth can not be successfully controlled unless the woodland is properly thinned and dead wood removed. In addition to this, if hollow trees are allowed to remain it is almost impossible to keep the insect in subjection. Another feature which should be pointed out is that although the first expense of cutting is large, the cost of caring for the area in future years is greatly reduced. Our data show that as a result of putting the roadsides in good condition for future treatment it has been possible to reduce the amount each year which must be expended for destroying the caterpillars and egg clusters.

Many experiments have been carried on for the purpose of decreasing the cost of spraying work. The adoption of the water tower on the tanks has materially assisted in this direction. A careful record of the spraying this year shows that over 360 miles of roadway were sprayed on both sides. By taking into account the entire cost, including labor, poison, supplies, fuel, and a liberal allowance for depreciation on the outfits used, it should be possible to spray roadsides for about $2 an acre.

If spraying could be relied on to control the gipsy moth, the problem would be greatly simplified, but unfortunately it is impossible to destroy all the caterpillars by spraying, and it is usually necessary to supplement the work either with burlap or tanglefoot, and to creosote all of the egg clusters that can be located during the winter. The cost of these methods is difficult to determine, as there is much variation in expense owing to the character of the infestation, the size of trees, and the locality in which the work is to be done. In general it may be said that woodland can be pruned, egg clusters creosoted, and brush cut and burned for $25 to $30 an acre; tanglefoot applied and tended for the season for $5 to $6; sprayed for $2 to $10; creosoted the following winter for $5, and should be kept free from injury by the gipsy moth for $2 an acre for each year thereafter.

VALUE OF NATURAL ENEMIES IN CONTROLLING GIPSY AND BROWN-TAIL MOTHS.

The influence exerted by native birds and insect enemies of the gipsy and brown-tail moths in this country has already been mentioned. As soon as the work was resumed by the State of Massachusetts, it was found that in some sections of the territory infested by the brown-tail moth large numbers of caterpillars were dying from a fungous disease. The matter was investigated by assistants employed by Mr. Kirkland in 1906, and specimens of the disease-bearing caterpillars were referred to Dr. Geo. E. Stone, botanist of the Massachusetts agricultural college, who stated that the cause of the death of the caterpillars was a fungus known as *Empusa aulicæ* Reichardt. This disease destroyed millions of caterpillars during the spring and early summer of 1906, and it has been found quite frequently since that time in Massachusetts, New Hampshire, and Maine. It works on both small caterpillars in the webs and the larger ones which feed during the early summer. This has assisted in checking the increase of the insect, especially in the sections of Massachusetts where it first became seriously injurious. The development of this fungus is influenced largely by weather conditions and during some years it has not greatly reduced the number of caterpillars.

During the past two or three years large numbers of caterpillars of the gipsy moth have died from a disease which is popularly known as the "wilt" or caterpillar cholera. This has been prevalent particularly in badly infested areas, especially in woodland, where many of the trees have been nearly defoliated. It seems to develop more rapidly on caterpillars which have not had sufficient nourishment, although in some places it was present where a considerable amount of foliage remained. The caterpillars attacked by this trouble become sluggish and soon die, the inside of the body becoming

semiliquid and putrid. When the cholera is prevalent, the trunks of trees below tanglefoot or burlap bands, where the caterpillars congregate, are sometimes completely covered with dead or dying larvæ. Isolated cases of caterpillars that had died from this disease were observed previous to the year 1900, but at that time the insects killed by it were relatively few. This trouble, which is supposed to be a disease known as "flacherie," was recognized as fatal to the silkworm many years ago.

Both of the diseases above mentioned are being carefully investigated by specialists of Harvard University in cooperation with the office of the Massachusetts state forester.

THE INTRODUCTION OF PARASITES AND NATURAL ENEMIES OF THE GIPSY AND BROWN-TAIL MOTHS.

Although the work of introducing parasites and natural enemies of the gipsy and brown-tail moths is entirely separate from the field work which is being carried on for the control of the insects mentioned, a brief statement is made concerning it, as it has an enormous practical bearing on the problem at hand.

It is evident that if the natural enemies of these insects can be introduced into the infested district in large numbers and be able to survive our climatic conditions and reproduce in the same ratio that they do in their native homes, it should be possible by this means to largely curtail the destruction that is now prevalent in New England. An effort in this direction has been carried on for the past four years by the Bureau of Entomology in cooperation with the State of Massachusetts, and Dr. L. O. Howard, Chief of the Bureau, has had the matter in charge.

A considerable number of parasites and natural enemies have been received and liberated, and conditions at the present time seem to warrant the hope that eventually much good will result from this work. It should be borne in mind, however, by some of those who are overenthusiastic as to the possibilities of controlling the insect pests by means of their parasites or natural enemies, that few cases are on record where work of this sort has been entirely effectual. Furthermore, it should be pointed out that the gipsy moth was liberated in this country nearly twenty years before it became such a serious pest as to cause widespread notice and the adoption of active measures for its suppression. This being the case, it will undoubtedly be several years before it will be possible to notice definite results from the reproduction of parasites in the field, and until it has been demonstrated that natural enemies can control the situation it is folly to curtail the amount of hand work which is being employed for the destruction of these pests.

VALUE OF THE WORK OF SUPPRESSION TO THE FARMER AND FRUIT GROWER.

From what has been already mentioned in this report it must be apparent that the strenuous effort being made to control the spread of the gipsy and brown-tail moths is of great value to farmers and fruit growers, especially to those who live outside the infested district. Should these insects spread over the United States and cover the same range which they now occupy in foreign countries the cost of controlling them and the damage which would result to orchards and to forest and shade trees would be enormous. The more progressive citizens throughout the country who understand the situation must appreciate the danger of the spread of these pests and are undoubtedly in sympathy with the work which is being carried on to restrict their increase. The residents of the infested district who have seen the devastation caused understand the necessity for thorough and persistent work if the trees are to be preserved. (See Pl. XII.) This is especially true in cities and towns where most of the shade trees have a desperate struggle to maintain an existence and where, owing to unfavorable conditions for tree growth, it is difficult to replace trees which have died from any cause. The hand methods of suppression which are being used are the best that have been devised and new or more effective methods are eagerly sought for by all who have a hand in managing the work.

The introduction of parasites and natural enemies, and the study and attempt to make use of the diseases of the insect which are known to exist, are being pushed as rapidly as possible. Both branches of the work are being conducted for the ultimate benefit of the property owners in the infested district and for the protection of all those who are fortunate enough to reside beyond its limits. The cost of protecting trees from such well-known insects as the San Jose scale, the codling moth, the elm leaf-beetle, and many other insects which prey upon them in more or less restricted localities throughout the United States, represents an enormous annual expenditure of money. This cost is ultimately met by the consumer of the products, and in the moth-infested district (fig. 19) by the tenant who lives on the property where treatment is applied.

SUGGESTIONS TO THE OWNERS OF PRIVATE PROPERTY IN THE INFESTED DISTRICTS.

It is evident that little progress can be made in controlling such insects as the gipsy and brown-tail moths without the hearty cooperation and intelligent interest of owners of private property in the infested districts. As a rule, owners have shown great appreciation of the work which is being carried on and many have expended large sums of money in caring for the trees on their own property. In sec-

VIEW SHOWING CONTRAST BETWEEN TREES PROTECTED FROM THE GIPSY AND BROWN-TAIL MOTHS AND THOSE UNPROTECTED. (ORIGINAL.)

[The tree at the left is an oak defoliated by brown-tail caterpillars and containing many of their webs at tips of branches.]

tions which are now only slightly infested less interest is taken in the matter because of the fact that few of the citizens thoroughly understand the damage which these pests are capable of inflicting.

Owners of orchards are advised that if modern methods of horticultural practice are adopted it is possible to put their trees on a paying commercial basis in spite of the presence of these insects.

Too many New England orchards yield no great revenue at the present time because of neglect, which is either due to lack of interest in caring for the trees or to ignorance of the possibility of making them sources of revenue. (See fig. 20.) Few intelligent farmers expect to harvest a profitable crop of potatoes without giving the land proper culture and treating the vines to protect them from the ravages of the potato beetle, and if the owner of fruit trees expects an income from this source he must give his orchards the best of care and protect the trees and fruit from the many insect enemies which prey upon them. The orchards of New England should be thoroughly pruned and trees which do not yield good varieties of fruit or which are in poor condition should be cut down and burned. Those remaining should be sprayed to destroy the insect pests which already attack them, and if the gipsy and brown-tail moths are present the additional expense of fighting them will not prevent the growing of a profitable crop.

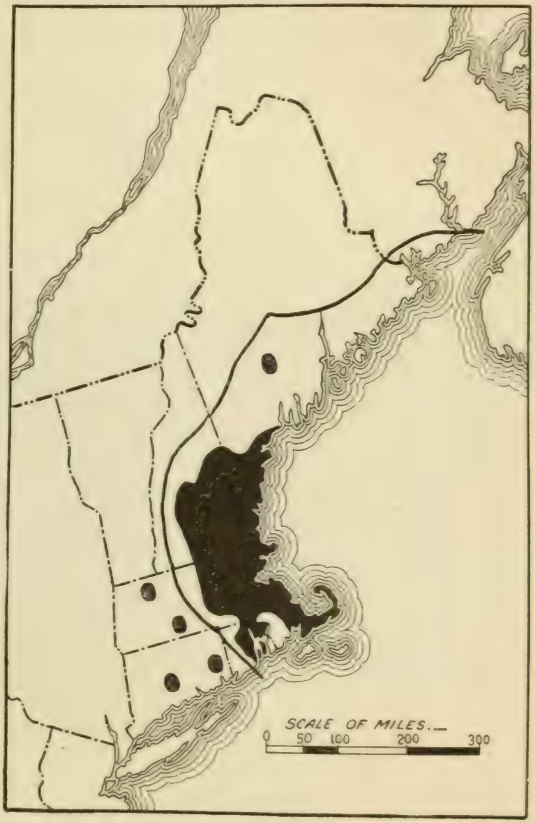


FIG. 19.—Map of New England, showing present area infested with the gipsy moth and the brown-tail moth. The black area is that infested with the gipsy moth; the brown-tail moth occupies all of the area to the right of the black line. (Original.)

Owners of woodland on which the trees are of marketable size should cut the timber if the gipsy moth is prevalent in the region. Care should be taken in doing this work to cut out all poor and

worthless trees, and if possible to leave for reforesting purposes vigorous specimens of ash, maple, pine, or coniferous trees of which the insect is not especially fond and which can be protected with the least possible expense. (See fig. 21.)

The planting or preservation of ash and hickory is recommended as the wood is of high value and these trees are not subject to attack by the brown-tail moth. Planting pine or other coniferous trees for reforesting purposes is also advisable, as the region is suited to their growth and these can be protected from moth injury at slight expense.

It is probable that many of the forests containing oak or other trees which are preferred by these insects must in time give way to species less subject to attack. In the meantime the owner should take advantage of the opportunity to harvest his merchant-

FIG. 20.—Neglected apple orchard in which the trees have been killed by the gipsy moth. (Original.)

able trees that are susceptible to attack and foster the growth of other species that will not be destroyed.

In cities and towns much progress can be made by cutting out neglected areas of worthless trees and in some sections the number of trees on the streets or on private property can be reduced and still provide as much shade as is desirable. If this work is intelligently done no injury will result to the property; in fact, a direct benefit will accrue and the cost of future work required to hold the moths within reasonable bounds will be greatly decreased.

THE OUTLOOK.

At the time the work on the gipsy moth was abandoned by the State of Massachusetts in 1900, over $1,000,000 had been spent in an attempt to exterminate the pest. Since the work was resumed in 1905 nearly $4,000,000 has been expended by the different States in

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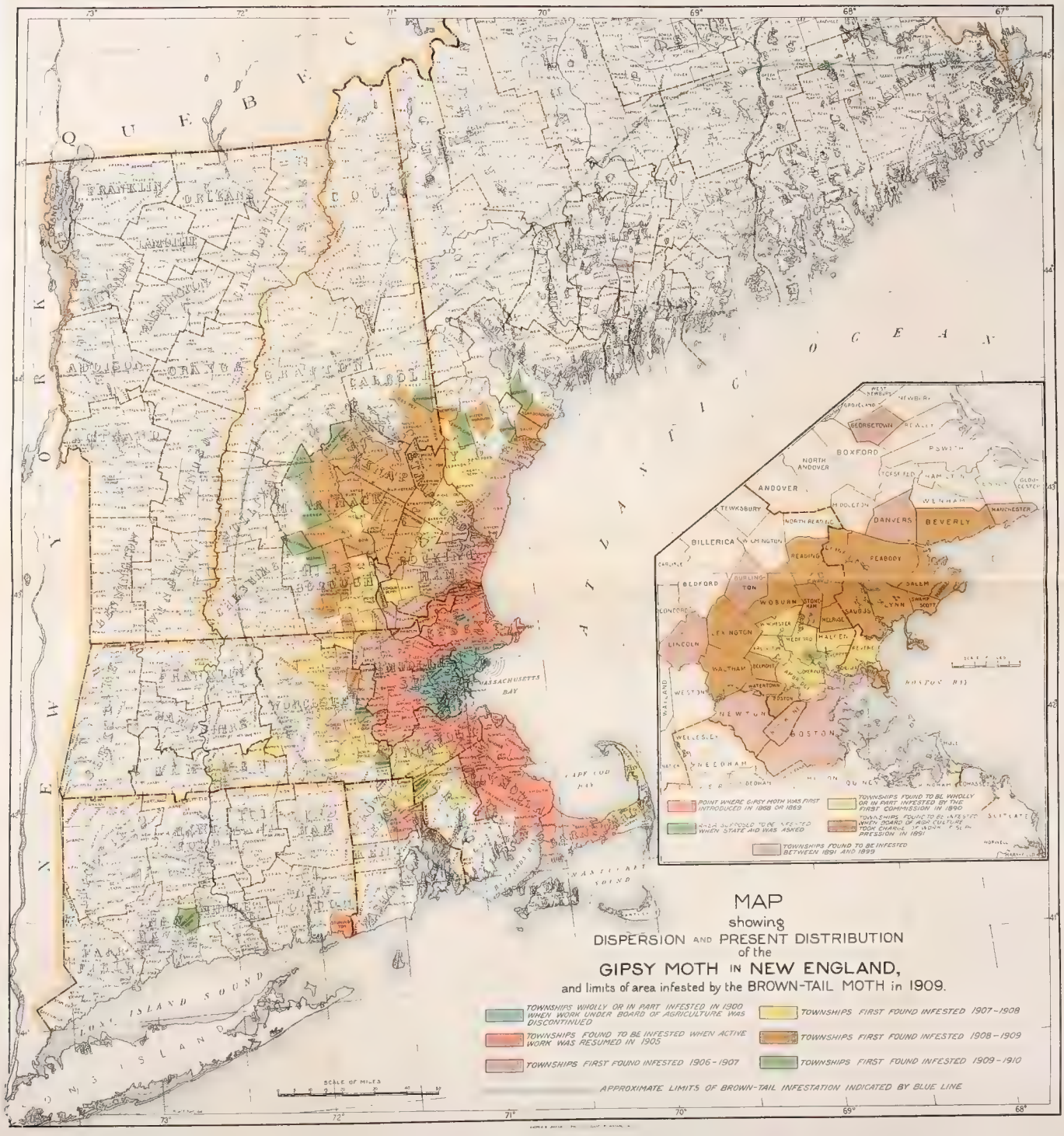

MAP

showing

DISPERSION AND PRESENT DISTRIBUTION

of the

GIPSY MOTH IN NEW ENGLAND,

and limits of area infested by the BROWN-TAIL MOTH in 1909.

TOWNSHIPS WHOLLY OR IN PART INFESTED IN 1900 WHEN WORK UNDER BOARD OF AGRICULTURE WAS DISCONTINUED

TOWNSHIPS FOUND TO BE INFESTED WHEN ACTIVE WORK WAS RESUMED IN 1905

TOWNSHIPS FIRST FOUND INFESTED 1906 - 1907

TOWNSHIPS FIRST FOUND INFESTED 1907 - 1908

TOWNSHIPS FIRST FOUND INFESTED 1908 - 1909

TOWNSHIPS FIRST FOUND INFESTED 1909 - 1910

APPROXIMATE LIMITS OF BROWN-TAIL INFESTATION INDICATED BY BLUE LINE

New England, which are infested with the gipsy or brown-tail moths, by private property owners, and by the United States Government, in an attempt to suppress them and to prevent their further dissemination. Every known means which promised good results in accomplishing this end has been tried in the field. The best methods of hand suppression have been carried on extensively and foreign countries have been literally ransacked for parasitic and predaceous enemies of the moths in the hope that they may in due time develop into a most important factor in checking the ravages of these insects. Owing to the ability of both sexes of the brown-tail moth to fly considerable distances, it has been impossible to prevent its rapid spread to new localities (see fig. 22), but the methods employed in the worst

FIG. 21.—View of a hill where all the timber was cut to prevent its destruction by the gipsy moth; pile of logs in the foreground. (Original.)

infested sections have afforded a large amount of relief from the injury which this insect causes.

Each year more or less territory has been found infested by the gipsy moth where the pest was not previously known to exist, so that the territory now known to be infested covers in the aggregate about 7,900 square miles. (See Pl. XIII.) At a conservative estimate three-fourths of this area consists of wooded land, while the balance is made up of residential sections, orchards, and farm lands. While the States in the infested section and the United States Government have done much work in the residential sections and along some of the principal roadways, it has been impossible to inspect the large forest area so as to determine the present state of infestation. So long as some of these areas remain badly infested it is difficult to prevent further dissemination of the gipsy moth. The methods adopted of keeping roadways clear has undoubtedly been a factor in preventing

many colonies from becoming established at distant points, but although nearly 250 miles of roadways have been treated in this manner in Massachusetts, there is still a very large mileage of trunk roads which can not be given proper attention with the funds at hand. The need of more work in the infested area is very urgent, as this is the only possible way to prevent the continued spread of the insect

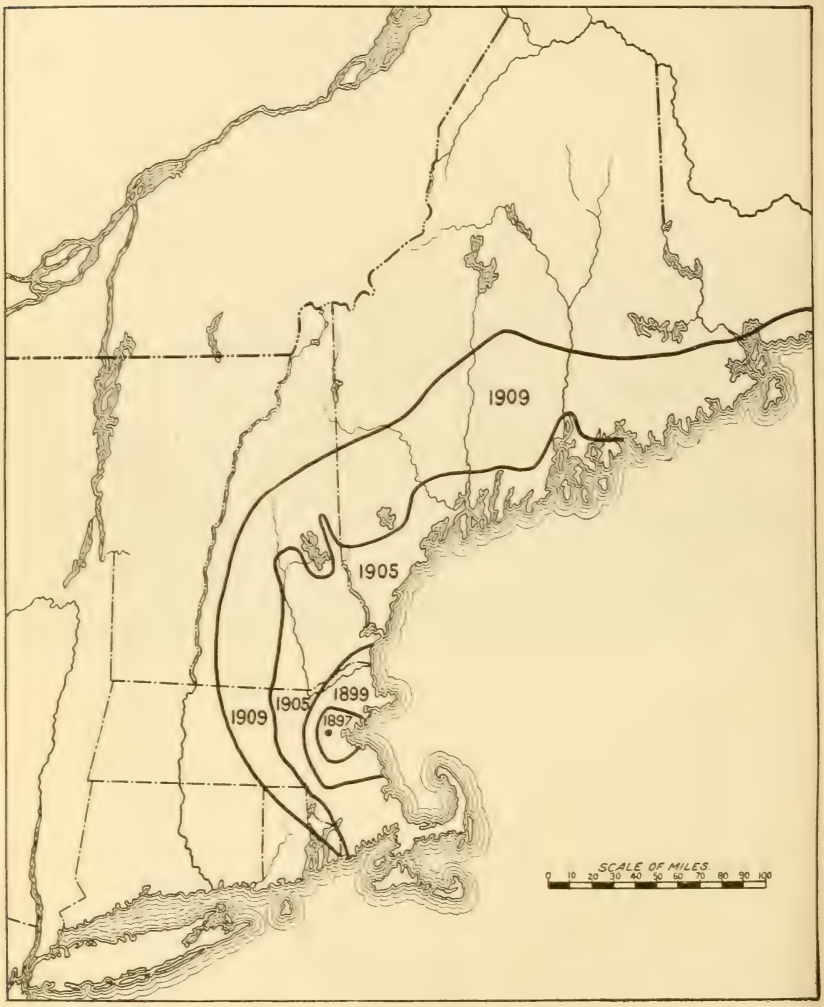

FIG. 22.—Map of New England, showing areas infested by the brown-tail moth from 1897 to 1909. (Original.)

until the parasites and natural enemies which are being introduced have an opportunity to show their capacity for reducing the pest. The importance of the work against this insect extends beyond state lines or sectional lines and should receive the cordial support of all who are interested in agriculture, horticulture, or forestry.

THE MORE IMPORTANT AMERICAN PUBLICATIONS ON THE GIPSY AND BROWN-TAIL MOTHS.

1889. Fernald, C. H.—Ocneria dispar, Notes.<Spec. Bul. Mass. Agr. Coll. Hatch Exp. Sta., pp. 3–8, figs. 4, November.

1892. Forbush, E. H., and Fernald, C. H.—Special report of the state board of agriculture on the work of extermination of the *Ocneria dispar* or gypsy moth. <39th Ann. Rep. Sec. Mass. State Bd. Agr., 1891, pp. 287–312, pls. 5. Boston.

1892. Fernald, C. H.—Report on insects. The gypsy moth (*Ocneria dispar*, L.). <Bul. 19, Mass. Agr. Coll. Hatch Exp. Sta., pp. 109–116. (Illustrated.)

1893. Forbush, E. H., and Fernald, C. H.—Report of the state board of agriculture on the work of extermination of the gypsy moth.<40th Ann. Rep. Sec. Mass. State Bd. Agr., 1892, pp. 259–297. (Illustrated.) Boston.

1894. Forbush, E. H., and Fernald, C. H.—Report of the state board of agriculture on the work of extermination of the gypsy moth.<41st Ann. Rep. Sec. Mass. State Bd. Agr., 1893, pp. 263–302, pls. 6, map. Boston.

1895. Forbush, E. H., and Fernald, C. H.—Report of the state board of agriculture on the work of extermination of the gypsy moth.<42d Ann. Rep. Sec. Mass. State Bd. Agr., 1894, pp. 235–270, pls. 5. Boston.

1896. Forbush, E. H., and Fernald, C. H.—The gypsy moth. *Porthetria dispar* (Linn.). Published under direction of the Massachusetts state board of agriculture. Boston. pp. 495 and appendices pp. I–C, pls. 66, maps 5, figs.

1896. Forbush, E. H., and Fernald, C. H.—Report of the state board of agriculture on the work of extermination of the gypsy moth.<43d Ann. Rep. Sec. Mass. State Bd. Agr., 1895, pp. 199–237, pls. 3. Boston.

1897. Fernald, C. H., and Forbush, E. H.—Report of the state board of agriculture on the work of extermination of the gypsy moth.<44th Ann. Rep. Sec. Mass. State Bd. Agr., 1896, pp. 349–433. (Illustrated.) Boston.

1897. Howard, L. O.—The gipsy moth in America.<Bul. 11, new series, Div. Ent., U. S. Dept. Agr., pp. 39, figs. 8.

1897. Fernald, C. H., and Kirkland, A. H.—The brown-tail moth.<Spec. Bul. Mass. Agr. Coll. Hatch Exp. Sta., pp. 15, fig. 1, pls. 4.

1898. Fernald, C. H., and Forbush, E. H.—Report of the state board of agriculture on the work of extermination of the gypsy moth.<45th Ann. Rep. Sec. Mass. State Bd. Agr., 1897, pp. 305–439. (Illustrated.) Boston.

1899. Fernald, C. H., and Forbush, E. H.—Report of the state board of agriculture on the work of exterminating the gypsy moth.<46th Ann. Rep. Sec. Mass. State Bd. Agr., 1898, pp. 409–481, figs. 2, pls. 11. Boston.

1900. Fernald, C. H., and Kirkland, A. H.—Report of the state board of agriculture on the work of exterminating the gypsy moth.<47th Ann. Rep. Sec. Mass. State Bd. Agr., 1899, pp. 339–388, pls. 7. Boston.

1901. Report of the state board of agriculture on the work of extermination of the gypsy moth.<48th Ann. Rep. Sec. Mass. State Bd. Agr., 1900, pp. 353–369. Boston.

1902. Report of committee on gypsy moth, insects and birds.<49th Ann. Rep. Sec. Mass. State Bd. Agr., pp. 313–319. Boston.

1903. Report of committee on gypsy moth, insects and birds.<50th Ann. Rep. Sec. Mass. State Bd. Agr., 1902, pp. 265–271, pl. 1. Boston.

1903. Fernald, C. H., and Kirkland, A. H.—The brown-tail moth (*Euproctis chrysorrhœa* L.) Published by Massachusetts state board of agriculture. Boston. pp. 73, pls. 14.

1905. Marlatt, C. L.—Report on the gypsy moth and the brown-tail moth, July, 1904.<Cir. 58, Bur. Ent., U. S. Dept. Agr., pp. 12, pl. 1, map 1.

1905. Sanderson, E. D.—The gypsy moth in New Hampshire.<Bul. 121, N. H. Coll. Agr. Exp. Sta., pp. 81–104, figs. 11, December.

1905. Hitchings, E. F.—The brown-tail moth in Maine.<Quart. Bul. Maine Dept. Agr., vol. 4, No. 4, pp. 101–127, December. (Illustrated.)

1906. Britton, W. E.—The gypsy moth in Connecticut.<5th Rep. State Ent. Conn. f. 1905, pp. 246–252, figs. 2–6.

1906. Kirkland, A. H.—First annual report of the Massachusetts superintendent for suppressing the gypsy and brown-tail moths. Public Document No. 73, January, 1906. Boston. pp. 161.

1906. Hitchings, E. F.—First annual report of the state entomologist on the brown-tail moth and other insect pests of the State of Maine, 1905, pp. 21. (Illustrated.)

1906. Felt, E. P.—The gypsy and brown-tail moths.<Bul. 103, N. Y. State Mus., pp. 20, pls. 10.

1907. Kirkland, A. H.—Second annual report of the Massachusetts superintendent for suppressing the gypsy and brown-tail moths. Public Document No. 73, January, 1907. Boston. pp. 170. (Illustrated.)

1907. Hitchings, E. F.—The gypsy moth in Maine.<2d Ann. Rep. State Ent. on the gypsy and brown-tail moths and other insect pests of the State of Maine, 1906, pp. 9–20, pl. 1, figs.

1907. Hitchings, E. F.—The brown-tail moth (*Euproctis chrisorrhoea*).<2d Ann. Rep. State Ent. on the gypsy and brown-tail moths and other insects pests of the State of Maine, pp. 21–26, fig. 6.

1907. Stene, A. E.—Report of the Rhode Island commissioner for the suppression of the gypsy and brown-tail moths for the year 1906. Providence. pp. 80, pls. 28.

1907. Britton, W. E.—Gypsy moth work in Connecticut.<6th Rep. State Ent. Conn. f. 1906, pp. 235–260, map, figs. 2–7, pls 3–10.

1908. Hitchings, E. F.—Brown-tail and gypsy moths.<3d Ann. Rep. State Ent. on the gypsy and brown-tail moths and other insect pests of the State of Maine, 1907, pp. 14–56, figs. 8–14, pls. 1, 6–20.

1908. Stene, A. E.—Report of the Rhode Island superintendent for the suppression of the gypsy and brown-tail moths for the year 1907. Providence. pp. 52, figs. 2, pls. 10.

1908. Britton, W. E.—Progress of the work of controlling the gypsy moth in Connecticut. 7th Rep. State Ent. Conn. f. 1907, pp. 300–312, pls. 7–13.

1908. Britton, W. E.—The brown-tail moth (*Euproctis chrysorrhaea* Linn.).<7th Rep. State Ent. Conn. f. 1907, pp. 313–318, figs. 1–4, pl. 14.

1908. Sanderson, E. D.—The gipsy and brown tail moths in New Hampshire.<Bul. 136, N. H. Agr. Exp. Sta., pp. 156, figs. 34, February.

1908. Kirkland, A. H.—Third annual report of the Massachusetts superintendent for suppressing the gypsy and brown-tail moths. Public Document No. 73, January, 1908. Boston. pp. 228. (Illustrated.)

1909. Britton, W. E.—Account of progress in suppressing the gypsy moth in Connecticut.<8th Rep. State Ent. Conn. f. 1908, pp. 772–777, pls. 42, 43.

1909. Worthley, L. H.—Fourth annual report of the Massachusetts superintendent for suppressing the gypsy and brown-tail moths. Public Document No. 73, January, 1909. Boston. pp. 75. (Illustrated.)

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